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SANKHYĀ

THE INDIAN JOURNAL OF STATISTICS

Editors: P. C. MAHALANOBIS, C. R. RAO

SERIES B, VOL. 25 NOVEMBER 1963 PARTS 1 & 2

INTRODUCING VOLUME TWENTYFIVE

1. The first number of *Sankhyā* : The Indian Journal of Statistics was published exactly thirty years, or one generation ago, in June 1933. In starting the twentyfifth volume I have much pleasure in announcing that Dr. C. Radhakrishna Rao would be associated with me as editor in future. The pleasure is all the greater because he is my former pupil; he attended my lectures as a student in the post-graduate course in statistics which was started for the first time in India in the University of Calcutta in 1941. After taking his M.A. degree in statistics, he joined the Indian Statistical Institute in 1943, and since then has been my colleague for twenty years. He has been, in actual fact, in charge of most of the editorial work for many years. I look forward to the day when he would assume full responsibility.

2. Having attained on this day the age of seventy, I may take the opportunity of looking both back and forward, a little. My mind goes back to 1933 when we were busy sending articles to the press for the first number of *Sankhyā*. I had started working on the multivariate distance several years earlier, and had examined a portion of a large volume of individual measurements of various anthropometric characters for a large number of castes and tribes in North India which had been published in 1891 by H. H. Risley. The measurements had been taken by the same small group of observers; and were, therefore, suitable for purposes of comparisons between castes and tribes. Karl Pearson had, however, condemned the material much earlier because of the discrepancies he had found in the average values given by Risley. After detailed scrutiny, I reached the conclusion that most of the discrepancies in individual measurements and indices could be traced to easily recognisable copying or printing mistakes, use of wrong figures taken from adjoining rows or columns, mistakes in entering index tables, or obvious arithmetical slips like a displacement of a decimal point in calculations. Out of 142 discrepancies in individual values, 133 could be corrected and corroborated with practical certainty by cross-checks with appropriate index numbers; in eight cases, the corrections were plausible although they could not be confirmed, while only one single measurement was really doubtful and had to be rejected out of a total of 12,197 individual measurements and a total of 8,600 indices given by Risley. The real defect in Risley's data had occurred during the calculation of average values; the primary data of individual measurements given by him could be used with safety, especially after applying the corrections which I had used.

3. I thought it would be useful to publish the revised values of Risley's data together with the detailed evidence in support of the corrections made by me.

My young colleagues, who were only three or four at that time, were strongly opposed to the publication of this paper. The scrutiny and reconciliation of discrepancies which I had carried out, they felt, could not be considered to be scientific work at all; they were eager to prevent the 'Professor' from exposing himself to ridicule in advanced countries by publishing this paper. However, due to a streak of contrariness and obstinacy, I printed this article in the first issue of the journal.[1]

4. It can be easily imagined with what joy and encouragement I read the following lines in a letter dated 14 August 1933 from Ronald Aylmer Fisher :—

> "You are most heartily to be congratulated on the new Journal, and very especially on your own contributions. The work on Risley's data will be most valuable. I shall hope to hear and read more of your contributions as time goes on. It is a splendid start."

It was characteristic of the most eminent statistician of the present age to have selected the paper on Risley's data for special mention.

5. Fisher himself had said somewhere that the first responsibility of a statistician is to cross-examine his data. I remember the vivid description he gave me, during his first visit to the Indian Statistical Institute in 1937, about his investigations in the monastry in Austria where Gregor Mendel had carried out his experiments on the inheritance of characters in sweet peas. Mendel had announced in his last scientific publication that he would publish in another paper his results on three factor segregation, but did not do so. Fisher had an almost irresistible urge to find out why Mendel ceased publication. Searching through old records, Fisher traced the original observations which Mendel had intended to use for his unpublished paper, and found that there was perfect agreement between observed and expected results. Fisher surmised that such agreement had raised a suspicion in Mendel's mind that his assistant, who had been helping him in these experiments, had deliberately changed the records to make them agree with expectations; Mendel had refrained from publishing the results as he could not guarantee their accuracy.[2]

6. My mind also goes back to the day when I had the good fortune to establish contact with R. A. Fisher. In 1923 I was working as Meteorologist in Calcutta in addition to teaching physics in the Calcutta University. Fisher was engaged in his researches on the design of experiments at Rothamsted Experimental Station, Harpenden. I had no connexion with agricultural research. By sheer chance, my attention was drawn to the question of "errors" in some agricultural field experiments, (in the form of a series of parallel plots sown with different varieties of rice, repeated in the same order in several blocks). I tried to eliminate, by crude graduation, differences in soil fertility and published a paper in an agricultural journal.[3] Fisher saw this paper and immediately sent me reprints of his early papers on the design of experiments and also the paper on the distribution of the ratio of two variances.

7. While struggling with the analysis of variety trials on paddy, I had begun to appreciate the need of radical improvements in agricultural field experiments. When I read Fisher's papers on this subject, I realized that he had not only solved the problem at a theoretical level but had also supplied the basic tables

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[1] A Revision of Risley's Anthropometric Data Relating to the Tribes and Castes of Bengal. *Sankhyā*, **1**, 1933, 76—105.

[2] R. A. Fisher : "Has Mendel's work been rediscovered ?" *Annals of Science*, **1**, 115—137, 1936.

[3] Probable error of field experiments in agriculture. *Agri. Jour. Ind.*, 1925, **20**, 96.

(for the z-distribution) to facilitate the use of his methods almost in a routine manner. I could also appreciate how great was his achievement. I believe, I can claim to be the first convert to the Fisherian view of statistics; I have also tried to extend his ideas to the design of sample surveys. For me, the discovery of Fisher, nearly forty years ago, was an important factor in deepening my interest in statistics which was further strengthened by the impressions of the memorable day I spent with him at Rothamsted Agricultural Station in 1926 when I met him for the first time.

8. I also recall that it was at Fisher's suggestion (as I came to know much later) that the newly established Imperial (now Indian) Council of Agricultural Research offered me in 1928 an annual grant of Rs. 2,500 (about £ 200, a princely sum for us in those days) to have a research assistant to take up some work in statistics. This grant led the way to the future development of the integrated programme of theoretical research, training, and applied projects which has been a characteristic feature of the Indian Statistical Institute.

9. Fisher came to our Institute on eight occasions. He always stayed in our house in the Institute in Calcutta. This gave me and my young colleagues the opportunity to profit by his stimulating discussions and suggestions. The special needs of an underdeveloped country like India, had made it continually necessary for us to increase the scope of application of statistical methods in widely differing subject fields in natural and social sciences, technology and economic planning. In such developments we received powerful support from R. A. Fisher, who quite early had a clear view of statistics as the new technology of the modern age.[4] He also first formulated, in a precise way, the concept of the Indian Statistical Institute as higher technological institution having an analogous function in respect of statistics, although on a much smaller scale, to that of the higher technological institutions like the Zurich Federal School of Technology or the Massachusetts Institute of Technology, which had been established a hundred years ago to provide an integrated programme of research, training and projects in the field of engineering and technology. In all these ways, Ronald Fisher had exercised more influence than any one else in the shaping of the policy and programme of the Indian Statistical Institute of which *Sankhyā* is the official organ.

10. R. A. Fisher had said somewhere that he had learnt his statistics through computation, I presume, in the dual sense that no theoretical formulae are of any value unless these can be used in numerical terms at a concrete level, and also that statisticians have to do the 'dirty work' of computation with their own hands. On the occasion of his first visit to the Institute in December 1937, he requested me to give him a hand calculating machine. For his seven subsequent visits, a desk calculator always used to be placed in his room in advance; he used such a calculator every day during his last stay in Calcutta up to the middle of February 1962.

11. I am recalling the two points made by him, namely, the need of cross-examining the data and the importance of computational work in statistics, because both these points are of crucial significance in the future development of statistics in India. During the last thirty years or the first generation of this journal, there has been a good deal of advance in the field of statistics in India. Indian statisticians have come to enjoy a good reputation abroad. Paradoxically, the Indian statistical system in respect of flow of factual information is recognized, within and outside the country, to be very weak. This is due to the fact that collection, processing and

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[4] Address by R. A. Fisher at the First Convocation of the Indian Statistical Institute, 12 February, 1962. Annual Review by P. C. Mahalanobis, *Indian Statistical Institute : Annual Report :* 1960-61, 78-81.

publication of official statistics are still treated as administrative matters, subject to the principle of a monopolistic jurisdiction of one single administrative agency for each type of information. The acceptability of statistical data is determined by the status of the authority responsible for their collection or publication, usually without any assessment of the reliability of the information.

12. The only way to improve the quality of official statistics in India is by testing their accuracy in accordance with accepted scientific principles, by using checks and cross-checks provided through multiple observations or through independent sources of information. Sample surveys, with multiple and parallel or inter-penetrating network of sub-samples, provide a speedy and economical way of ascertaining the margin of uncertainty in an objective manner. It has been, therefore, the policy of this journal to attach special importance to methods and practical applications of sample surveys. The need of doing this would continue in future.

13. In the second generation, if I may call it so, of the journal, we feel one of its important tasks must be to foster the growth of the spirit of criticism without which the advancement of science is not possible. In the early years, we used to publish book reviews and also selective reviews and abstracts of statistical papers published elsewhere; much to our regret, we have not been able to maintain these two features. We feel it may be particularly helpful to use reviews of articles and books, in a purposeful manner, to promote the growth of a critical appreciation of the quality of research and of advances in the collection, processing and analysis of statistical information in India. In future, it would be our policy to welcome reviews both of papers published in journals and books.

14. From the very beginning, to help in the advancement of statistics in an underdeveloped country like India, we had adopted certain lines of policy which are somewhat unorthodox, for example, reprinting papers published elsewhere to make them more easily available in India, publishing statistical materials and data for purposes of record, or giving attention to primary work like scrutiny of data and computations. It is our intention to continue these features. At the same time, we shall continue to welcome contributions from all over the world, as we have been doing from the first issue of the journal.

15. I should like to take this opportunity of placing on record my sense of gratitude to the late Narendra Nath Mookerjee, who with characteristic generosity had helped in the publication of the journal from the Art Press, in the early years. I remember the services rendered by my two young colleagues, Subhendu Sekhar Bose and Sudhir Kumar Banerjee, who passed away at a very early age. In recent years, we are grateful for the help we have received from Anikendra Mahalanobis, Krishna Birendra Goswami and Dyutish Ranjan Banerjee in the publication of this journal. We offer our sincere thanks to the workers of the Eka Press, who have always helped ungrudgingly in printing the journal.

16. It was an adventure, even foolhardy, to have started a statistical journal in India thirty years ago when our resources in research and in material equipment were meagre. It is because of the friendly cooperation and support which we have been receiving from within and outside India that this journal could make a place of its own in public esteem. We offer our most sincere thanks to our friends and contributors in India and abroad for their kind cooperation, and seek their continuing support in future.

29 June, 1963

P. C. Mahalanobis

PROBLEMS OF REGIONALIZATION FOR THE DEVELOPMENT OF NATIONAL ECONOMY

By L. S. BHAT and M. N. PAL
Indian Statistical Institute
and
I. V. KOMAR and K. M. POPOV
Institute of Geography, Academy of Sciences of the USSR, Moscow

SUMMARY. Utilization of the available experience in regionalization for national economic development encounters a number of difficulties. These are due to inadequate preliminary studies, incompleteness of statistical data, the lack of proper estimates for long-range targets of national economic development, a tendency towards economic autarchy in some parts of the country.

To be effective the regionalization calls for a high level of national planning, a proper relationship between the national (principal) and local goals, a permanent development along the road of social progress.

INTRODUCTION

During the last few years close cooperation between the Indian and the Soviet scientists was started for studying the problems of regionalization. This cooperation involved useful discussions regarding the principles and methods of regional studies and defining lines of further researches.

The purpose of the paper is to draw attention to some important aspects of the problems of regionalization. The principles regarding which there is a common approach by both the Indian and the Soviet scientists are discussed. Some problems which are solved in peculiar ways by each country are also discussed.

IMPORTANCE OF THE PROBLEM

The building of national economy in the less developed countries requires comprehensive utilization of natural resources and manpower as also fundamental changes in the structure and distribution of the economy. This accounts for an increased interest in the problems of regionalization and in the study of the geographical situation, physical environment and economic potentialities of various regions as parts of the national economic set-up.

It is necessary to take into account the possibilities of the resource development of each region in coordination with national targets for the establishment of a stable national economy and drawing in its creation the whole population of the country.

Regionalization is important for every country, especially for the countries with vast areas, diverse natural resources and economic conditions and a mixed ethnical composition of the population. The problem is very important for the countries with growing number of public sector undertakings.

Much of world experience in regionalization has been accumulated by now. It must be put to use with due criticism. Special attention is required for the problems of general economic (integral) regionalization that have direct bearing on national economic planning. The socialist countries have great experience in such regionalization which is a basic feature of their national economic planning.

REGIONALIZATION IN THE USSR

Methodology. General economic regionalization in the USSR is based on the following principles.

(a) An economic region is a part of the country, an objective reality which arises as a result of territorial division of labour.

(b) Regionalization is based on economic principles. This does not exclude rather emphasizes the necessity to take into account regional natural resources, its manpower and cultural heritage of the past. It should, however, be remembered that in the final analysis it is the process of production that binds all these elements together and with the territory itself. Here lies the reason that one-sided "market zone" orientation is unacceptable as a base for economic regionalization.

(c) A region is defined as a territorial-production complex with a combined structure of economy, which at the same time has pronounced specialization. The leading industries of a region are interlinked and constitute the core of the territorial-production complex. Such large economic units arise on the basis of common territory (integrated transport system, integrated systems of power generation and water-supply etc.), concentration, extraction and processing of raw materials and by-products in the same region by successive stages. The establishment of such units also involves industrial cooperation, close technological combination of industries, (especially the latest modern industries), effective use of the available labour force and a number of other important factors. Many associated and auxiliary industries arise in connection with the basic industrial framework of a region.

Economic specialization of each region should be encouraged only within reasonable limits as undue emphasis on specialization may involve excessive expenditures on inter-regional transportation, underexploitation of the potentials of a region and instability of its economy.

(d) An integral economic region develops in the process of productive activity of its inhabitants. It changes not only in time but also territorially as it may expand or be broken down into smaller regions. It is, therefore, essential, when delimiting a region, to take into account not only the present or past developments but also its prospects which can be evaluated on the basis of the potentialities against the background of nation-wide economic development programme. The relative instability of the boundaries of economic regions suggest the necessity to follow closely their evolution and to revise from time to time the general pattern of regionalization.

(e) Economic regionalization is based on the principle of maximum productivity of social labour within each region as well as in the whole system of regions. This very important criterion makes it possible to test in the course of a regionalization programme the effectiveness and vitality of economic specialization that has arisen in or is being planned for an economic region. It can also provide a measure of the effectiveness of allied and auxiliary industries that develop in connection with the regional basic industrial framework.

(f) General economic regionalization provides a scientific basis for regional economic planning and is thus the objective fundamental principle for the administrative division of a country. The proper correlation of economic regionalization and the division of a country into national-administrative regions are of special significance. If this correlation is to be achieved economic regionalization should provide broad opportunities for the development of all nationalities of a country and should not infringe on the rights of national self-governing territories. Small national territorial units may be subdivisions of an economic region while larger national regions may constitute an economic region each. National regions with very large territories may consist of several economic regions.

METHODS OF REGIONALIZATION

As regionalization involves a great variety of diversified factors it cannot be implemented without adequate statistics on the natural features and conditions, population and economy of the country concerned. Economic regionalization which makes wide use of statistics on the natural resources of a country is to be preceded by the investigation in physico-geographical regionalization. It has, however, been found from experience that physico-geographical natural regions do not coincide with economic regions, although, they do indicate in a general way the territorial distribution of natural resources. Moreover, economic regions include very often parts of different physico-geographical regions because diversity of natural resources is essential for the development and effective functioning of a given territorial-production complex.

Industrial and agricultural development plans for integrated utilization of the resources of a region may be used for advantage of bringing out the main development centres of economic regions or their "nodes". The availability of a long-term programme for the economic development of the country concerned is of special importance in any regionalization.

The first stage of general economic regionalization of a country is the elaboration of a draft plan for the territorial distribution of its chief industrial and agricultural production bases. Such bases are outlined either as combinations of industries or production complexes.

The first stage of regionalization also includes the elaboration of the basic economic set-up of the regions to be delimited and their basic specialization trends ("project method"). These two factors determine the fundamental conception of a region and are used to trace its preliminary geographic boundaries. When delimiting an economic region due account should be taken of the geographical distribution of major industries. An economic region should also incorporate adjacent territories which have resources vital for the effective operation of the region's production complex. The first stage of regionalization should besides that reveal the region-forming role of major economic centres and cities.

An important factor for elaborating an optimal structure of regional complexes is inter-relation of various industries which is an objective phenomenon. The most important consideration in this respect is the economic effectiveness of the combination of the elements in the regional production complex (combination of leading industries; combination of leading, associated and auxiliary industries; correlation of industry, agriculture and transport).

Professor Kolosovsky suggested a useful method of "power production cycles", i.e., combinations of typical production processes that can be used for evaluating the role of technology in the formation of regional complexes. Such cycles include the pyro-metallurgical cycles, the oil-power and chemical cycle, a group of hydro-electric and industrial cycles and so on.

The next important stage of regionalization is a detailed analysis of economic ties within the region and its economic connections with the rest of the country. The analysis of these inter-and intra-regional ties, both already established and in the process of formation, is supplemented by a study of the transportation system and ways and means of its improvement. This work outlines the role of the region in the country as related to other regions and makes it possible to adjust the economic pattern of the regional complex and its boundaries. Mathematical programming for analyzing transportation within and between economic regions may be used with advantage for the purposes mentioned above.

Closely connected with the second stage of the regionalization programme is its third stage which is aimed to divide the region into smaller economic units and to determine an inner network of centres (nodes) and territories gravitating towards these centres. It should be emphasized that as a result of industrialization a growing number of regions receive a nodal structure.

The division of the territory of a region makes it possible to adjust with greater accuracy the boundaries of the region that has been delimited as well as its economic structure.

The basic principles of integral regionalization evolved above may be applied not only to delimitation of a major economic region, but with certain modifications are also of use for delimitation of smaller tacsonomic units. Smaller internal sub-regions have usually more pronounced economic specialization and less developed associated and auxiliary industries. The factor of economic gravitation is of paramount importance for delimiting the smallest territorial units.

The regionalization programme also includes at its final stage elaboration of a number of balance sheets. The balance sheet method is gaining ground as modern computers and computation techniques make it possible to study in greater details the economic structure of regions, to draw up integrated inter-industrial and inter-regional balances of production and distribution of commodities and to build economic and mathematical models of planned economy for separate regions and the country as a whole. These new methods are intensively worked out in the USSR.

THE REGIONAL FRAMEWORK IN THE USSR

The first attempt at delimiting large economic regions for planning purposes were made soon after the formation of the Soviet State when on V. I. Lenin's initiative an electrification plan was drawn up for Russia.

The macro-economic regions, delimiting USSR, are large specialized production complexes of the industrial and industrial-agricultural type. In the Asiatic part of the Soviet Union such regions have smaller populations while their territories are much larger than in the European—more densely populated part of the country.

The Russian Federation and the Ukrainian Soviet Socialist Republic which are the largest Union Republics in respect of population are sub-divided into several major economic regions.

Each major economic region includes a group of smaller closely interconnected production complexes which constitute the economic base of small Union Republics, Autonomous Republics and such administrative units as "kray" and "oblaste". These meso-regions are in their turn sub-divided into more fractional regions.

The framework of economic regions in the USSR is modified in accordance with economic development and also due to improvements in the methods of regionalization. The administrative division of the country is also revised from time to time.

THE EXPERIENCE OF INDIA : MACRO-REGIONS

The need for regional approach to planning arises because of the sharp regional contrasts in respect of natural conditions, distribution of resources and levels of economic development, which are common to countries of large size like the USSR and India. In the USSR, regionalization for planning is always considered as an important aspect concerning the development of the national economy. Identification of regional production complexes which arise as a result of interaction of productive forces is the salient feature of delimitation of economic regions in the USSR.

A macro-economic region thus delimited is large in size and includes parts or whole of different natural regions, agricultural regions etc., so as to make it an economic region having maximum self-sufficiency in respect of such resources that are necessary for its rational economic specialization.

The primary aim of such maximum self-sufficiency is to avoid long haulage of goods which are bound to be uneconomical in a country of long distances, separating the region of production and consumption. Macro-economic regions serve as a useful link between regions of the lower order and the nation as a whole in respect of the development of the national economy.

There are in India some major aspects of planning like the development of basic and heavy industries which are vital to the development of the national economy and also induce regional development at a faster rate. But the natural resources like minerals, forests and power potentials are highly localized and hence there is need for identifying broad regions (macro-economic regions) to include group of states or even part of different states for purposes of efficient production and utilization of their resources. In other words, each macro-economic region would tend to develop production complexes for which the region has the best advantages. Such an approach will have far reaching effects on the competing tendency of each state to develop basic and heavy industries. Pending more detailed studies six macro-economic regions emerge based on the distribution of resources and possibilities of developing the regional production complexes.

(1) South India: comprising Madras, Kerala, Mysore states and major parts of Andhra Pradesh state with their three nuclei of industrial complexes that are likely to develop around Bhadravati (iron ore, manganese, power and forestry resources), Neyveli-Salem (ironore-lignite) and Horpet-Sandur (ironore-making use of coal from Singareni).

(2) Western India: comprising two states—Maharashtra and Gujarat with the production complex rooted to textiles and associated industries and the newly emerging oil fields.

(3) Central India: comprising Madhya Pradesh and Uttar Pradesh states (industrial complex based on iron ore from Chanda-Bastar area and coal from Singareni-Damodar coal fields).

(4) North-Eastern India: comprising Bihar, West Bengal, Orissa states and parts of Uttar Pradesh with the industrial complex of the Damodar region as the base.

(5) North Western India: comprising Rajasthan, Punjab, Union Territories and Jammu and Kashmir (power from Bhakra-Nangal and minerals of Aravalli hills and coal from Rajasthan).

(6) Assam: production complex based on forestry and minerals. This forms actually part of the North Eastern India with Calcutta as the major node port.

It should be mentioned in this connection that the proposed framework of regions for power development roughly commensurate the boundaries of the macro-economic regions. This raises the question what factors should be considered in the delimitation of macro-economic regions in further detailed studies?

The emerging picture of the macro-economic regions could then be adapted to the administrative structure.

Since regionalization is for the development of national economy by the achievement of maximum productivity in each region and in the system of regions as a whole with the aim of securing an approximate regional balance of national economy, these regions should have their own economic specializations. Each will have certain production advantages which will have to be tapped to its maximum possible extent. The results of comparative production advantages will finally be distributed among all regions through trade. But there should be some sort of balance, that is, the balance in export-import situation, since a region cannot be planned to depend economically on other regions for a long time.

Naturally, macro-economic regions need not be homogeneous. They are rather heterogeneous in one or more characteristics, but they are unit areas—functionally or in relation to possibilities of economic specialization and development of associated and auxiliary industries.

The Indian Statistical Institute carries out some experimental works for applying the concept of macro-economic regions in planning. In a long-term planning some sort of balance in export-import situation between each region and the rest of India, together with other countries, should be achieved. This involves inter-macro-regional, inter-industrial and inter-temporal study.

Professor Mahalanobis did the inter-industrial (or the inter-sectoral) study for the nation as a whole in formulating the five year plans of India. He proposed four-sector national model. V. G. Bhatia of the Indian Statistical Institute has developed a theoretical multi-regional, multi-sectoral programming model for economic development. But there are many difficulties in using these works because of the lack of full data needed.

Shri Pitambar Pant of the Planning Commission, India and of the Indian Statistical Institute suggested a short cut method for getting quick results needed at this stage of continued planning. According to him, since a macro-economic region, e.g., South India should be planned to be economically self-supporting within a period ending, say, in 1975-76, we can first (a) estimate the requirements of commodities for South Indian consumption in 1975-76; then we can examine (b) how much of these commodities would possibly be produced in South India, (c) how much of them must be imported and lastly (d) whether the cost of additional commodities produced in South India is more than the cost of imported goods. The work is in progress in this line in the Regional Survey Unit of the Indian Statistical Institute.

Since household consumption of commodities were available in details for 1957-58, estimates of total South Indian consumer expenditure were made from these data for different population fractiles when per capita consumer expenditures had been in increasing order. Here we postulated an annual increase of total household consumption and a more rapid increase in per capita consumer expenditure in the population classes of lower consumer expenditure. The detailed table showing the requirements of commodities for total South Indian consumption in 1975-76 had been worked out knowing the household consumption and using the existing inter-industrial and other relations (government consumption, capital formation, stock etc.).

Having determined the requirements of commodities for South Indian consumption in 1975-76, we should examine the capacity of production and finally the export-import of commodities. The detailed quantitative values for the production and the export-import relation are just being worked out at present. In this work various latest quantitative methods are applied.

THE HIERARCHY OF REGIONS

A careful study is necessary for the problem of evolving a hierarchy of regions within macro-economic regions. The need for identification of such regions in a macro-economic region is to implement the action programme easily and rationally in the context of developing the macro-economic region.

Regions for resource development or planning regions are distinct from other regions. There are different types of planning regions: a river basin, a soil conservation district, a major endemic famine zone, an area of chronic unemployment or of a major development project. These are unique and ad hoc planning regions, and should not be confused with regions for over-all resource development. Should a planning region be a composite (integrated) region? Instead of composite planning region, should we have more than one type at least in the early stages of economic transformation? Then there are market regions, urban fields, industrial regions, but can we separate the different sectors of resource development into water-tight compartments particularly when integrated and balanced regional development is our goal? Here, there is scope for systematic research on the theory and practice of regional concept.

Since the administrative units (states districts) are the main authorities in the execution of the plans, it has become necessary to identify a suitable framework of fractional (detailed) regions for over-all resource development and to adapt it to the administrative structure. Here the assumption is that administrative units can function as unit areas for planning, so long as the regional components are given due weightage.

Based on the analysis of distribution of resources, regional pattern of development and potentials, a tentative framework of fractional regions and subregions (so-called formal regions) for regional planning is identified in India. Boundaries of these regions and subregions are adapted to the nearest district boundary to facilitate the formulation of rational policy relating to each region's norm of development with minimum deviation from the existing administrative set-up. As a rule the subregions are identified within each given State. At the same time, in typological sense, they are grouped in eleven major regions.

Areas around the metropolitan cities are treated separately since the problems for development in these areas are distinct from the rest. Likewise the Godavari through Telegana, Rayalseema, Coimbatore plateau and Mysore plateau are treated separately as they do not strictly conform to the envisaged regional framework. It must however be stressed that regions for resource planning must remain flexible as their character changes during the phase of economic development changing technological possibilities and development policies.

The delineation of underdeveloped areas in macro-economic regions is another important problem. The selection of components of development is a difficult task. The lack of detailed areal data further adds to the problem. An attempt to elaborate a tentative framework of regions with different development level was undertaken by M. N. Pal (Indian Statistical Institute) relating to South India's macro-economic region.

For each district of South India eight components were selected (indices of concentration of total industrial labour, factory workers, male immigrants, labour employed in transport and commercial services, population employed in services, index of urbanism, index of land productivity). All the eight components were combined by the method of principal component to get a final composite index of development. Combination, however, have been possible by considering the relative economic importance of each character. The results were mapped and the regional grouping of districts did emerge out of this.

The nature of development of each region, especially less-developed, was analyzed and the preliminary observations on strategy of regional planning were formulated. These preliminary observations are quite helpful in working out the production figures.

We can determine the preliminary estimate of total investment for each of such regions when total investment of the macro-region as a whole is known. Since one of the main objectives of regional planning is to reduce disparity of economic development between regions it is logical to assume that the perspective rate of growth of per capita income for each region should be inversely proportional to the composite index of its present stage of economic development. Then some adjustments of preliminary estimates of investment should be done, in conforming to the expenses of the projects to be undertaken with due consideration of regional potentialities and income generation.

CONCLUSIONS

Some important aspects of regionalization and regional planning have been illustrated. But such planning has to be done within the wider frame-work of economic planning for the nation as a whole, i.e., for the totality of all macro-economic regions; this is essential. Much further work will be necessary not only on regionalization but also on other connected and essential questions, among which may be mentioned,

(a) the perspective structure of national economy in the system of macro-economic regions with the *fundamental objective* of optimizing the national income to be generated by the rational utilization of all productive forces of the system;

(b) the relative level of economy that can be achieved in different macro-economic regions in the context of the above perspectivity; and

(c) the relationship among different macro-economic regions, of the system in respect of the distributive aspects of the economy.

The solution of all these questions would necessarily involve the choice of social objectives and production targets. For example, the rational choice of location of an industry may go in favour of one macro-region from considerations of the maximization of the national income, while the same choice may go in favour of another macro-region from considerations of reducing macro-regional disparities in the level of production. In such a situation, in initial phases of development, the location of large scale modern industrial enterprises should be decided on grounds of the generation of maximum national income together with a concurrent policy of redistribution of national income to reduce disparities in the level of living of the people with preferential treatment for the welfare of less-developed macro-regions or sub-regions.

However, researches and experiments are going on in India, in the Planning Commission in which the Indian Statistical Institute is participating to study these problems.

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ESTIMATION OF QUALITY ELASTICITIES FOR CERTAIN COMMODITIES FROM NATIONAL SAMPLE SURVEY DATA*

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SUMMARY. This paper seeks to examine the extent of quality preferences in rural and urban areas of India. The concept of 'quality elasticity' is used, and such elasticities are computed for selected commodities by making use of concentration curves. In some cases, however, weighted regression is used. These studies are based on consumption data provided by the National Sample Survey of India.

1. INTRODUCTION

In surveys of household expenditures the items recorded in the schedules are not uniform homogeneous commodities but represent aggregates of more or less closely related commodities. An item of expenditure in a household expenditure schedule is to be regarded as a composite item made up of a number of constituent items. These constituent items may in some cases be the different varieties of the same commodity, each of different quality and bought at different prices. The variation in prices paid for a commodity arises primarily from quality differences, but regional, seasonal and price discriminatory factors may also contribute to the variation. To explain this variation, we use the concept of *quality elasticity* (Prais and Houthakker, 1955) which is analogous to and complements the expenditure elasticity.

The notion of *quality* of a commodity is esentially multidimensional and its complete specification is often very laborious. However, in so far as the differences in the quality of commodities are voluntarily chosen by the consumer in the market supposed to be in equilibrium, the multidimensional elements are brought under the measuring rod of money. If the variations in prices by regional, seasonal or prices discriminatory factors are not of much importance, the average price paid for the commodity may be taken as an indicator of the quality of the commodity. The average prices are, of course, calculated by dividing expenditure on the commodity by the quantity bought and, to this extent, data regarding quantity and value of consumption are necessary in the analysis of quality sensitiveness.

The quality, which is reflected in the average price paid for the commodity, and the quantity of the commodity are supposed to depend on the standard of living of the household, that is, on the per capita total expenditure of the household. The quality sensitiveness is measured by the quality elasticity which represents, in relative terms, the increase in the average price paid by the consumer as a result of a unit rise in his total expenditure.

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*This is a slightly expanded version of a paper presented at the Fortyeighth Session of the Indian Science Congress, Roorkee, January 1961.

An attempt has been made in this paper to estimate the quality elasticities for some important groups of consumer items by using the available cross-section materials. The method of estimation followed in this paper is somewhat different from the usual regression analysis and is, therefore, briefly described in Section 2. Also, certain broad tests of consistency of the new approach have been discussed. The main results are presented in Section 3, while a few concluding remarks are made in the last section.

2. THE METHOD OF CONCENTRATION CURVES

The graphical or the method of least squares becomes complicated in view of the fact that the available cross-section data are generally grouped in size classes of per capita total expenditure of households. What one might possibly get from published sources of consumption materials, as are required for the present types of problems, are some weighted arithmetic averages of consumption (both quantity and value, although the latter is more readily available) of different groups of consumer items and the average total expenditure per capita in each of the size classes. Percentage distribution of population in these classes is also provided apart from other demographic or other classificatory characteristics. The selection of sample households in these surveys is often complicated involving as it does two or more stages; at each stage the sampling units are selected with varying probabilities. This is in fact the case with the National Sample Survey. The National Sample Survey of India has been collecting valuable data relating to household expenditure since 1951. These materials are published in the form of grouped data, the groups being formed according to monthly per capita expenditure of the household. Twelve groups have been distinguished :—Rs. 0–8, 8–11, 11–13, 13–15, 15–18, 18–21, 21–24, 24–28, 28–34, 34–43, 43–55 and 55 and above, and for each group, say i ($i = 1, 2, \ldots, 12$) the following details are given :

$\bar{V}_i$, average value of consumption of the specific commodity (Rs); $\bar{Q}_i$, average quantity of consumption of the specific commodity (e.g. seers); $\bar{E}_i$, average total expenditure on all commodities (Rs); w_i, proportion of population; and $\bar{P}_i$, average price paid for the commodity, which is simply the ratio $\frac{\bar{V}_i}{\bar{Q}_i}$ of value to quantity.

The model assumed here for the quality relationship is of the form

$$\psi_P(E) = \mathcal{E}(P \mid E) = \text{const } E^{\eta_P} \qquad \ldots \quad (2.1)$$

where P is the average price paid for the commodity in question by the households spending a total expenditure E; η_P is the quality elasticity of the specific item. In estimating the quality equation (2.1), the conventional method of regression has been applied to National Sample Survey data by some workers (Biswas, 1960; Biswas and Bose, 1961); but it appears that this method is not quite appropriate. An alternative method is used in this paper.

The alternative method adopted here is fully discussed elsewhere by the author (Iyengar, 1960) in the context of computing the Engel elasticities from grouped data. This method is based on the use of concentration curves. These curves show proportions of consumption (value or quantity) (vertical axis) against various proportions of population (horizontal axis) spending up to a given level of total expenditure per capita. Two types of concentration curves may be distinguished : one describing the proportions of aggregate total expenditure and the other describing the proportions of aggregate consumption of specific commodities in terms of proportions of population. These two types are respectively called the *Lorenz curve* and the *specific concentration curve* (Roy, Laha and Chakravarti, 1959). These two types of curves may be easily constructed from the available National Sample Survey data. The method of concentration curves which makes use of these two curves is based, however, on the assumptions of constant elasticity as in (2.1) and log-normality of the distribution of total expenditure. The validity of the latter assumption has been examined in a number of places (Iyengar, 1960; Roy and Dhar, 1959; Bhattacharya and Iyengar, 1961).

For purposes of computing the quality elasticity for specific commodities the following additional assumptions are made about the Engel curves.

$$\psi_V(E) = \mathcal{E}(V \mid E) = \text{const } E^{\eta_V} \quad \ldots \quad (2.2)$$

$$\psi_Q(E) = \mathcal{E}(Q \mid E) = \text{const } E^{\eta_Q} \quad \ldots \quad (2.3)$$

Equations (2.2) and (2.3), which represent respectively the Engel curves for the value and quantity of consumption of the specific commodity, imply again constant elasticities. The parameters η_V and η_Q are the value and quantity elasticities respectively of the specific commodity. It follows at once that the value elasticity is the sum of the quantity and price elasticities. This is quite generally true even in the absence of constant elasticity assumptions, that is,

$$\eta_P = \eta_V - \eta_Q. \quad \ldots \quad (2.4)$$

In order to get the quality elasticity the following curves are needed— (a) the Lorenz curve for the distribution of E, (b) the specific concentration curve for the distribution of $\psi_V(E)$ and (c) the specific concentration curve for the distribution of $\psi_Q(E)$; these will provide estimates of η_V and η_Q, and hence an estimate of η_P. The elasticity (for value or quantity) is derived as the ratio of the standard normal deviate of the ordinate of the specific concentration curve to that of the ordinate of the Lorenz curve corresponding to the median total expenditure. In order to be sure that this method gives consistent results one may draw the concentration curve for $\psi_P(E)$ and derive independently an estimate of η_P which may be compared with the difference $\eta_V - \eta_Q$.

Quite frequently, econometricians are interested in building up demand relationships of the form

$$\mathcal{E}(Q\,|\,E,\ P) = \text{const } E^{\eta_{QE}}\, P^{\eta_{QP}} \qquad \dots \quad (2.5)$$

which relates the quantity of consumption of the specific commodity to its own price and the standard of living of the household as measured by the total expenditure (Tintner and Iyengar, 1960). The parameters η_{QE} and η_{QP} are the partial demand elasticities with respect to total expenditure and the average price paid for the commodity. The partial elasticities are related to the quantity and quality elasticities in a simple manner. Now, taking expectation on (2.5) with respect to P one gets

$$\underset{P}{\mathcal{E}}\, \mathcal{E}\,(Q\,|\,E,\ P) = \mathcal{E}(Q\,|\,E) = \text{const } E^{\eta_{QE}+\eta_P\eta_{QP}} \qquad \dots \quad (2.6)$$

Since (2.6) is to be same as $\psi_Q(E)$ it follows

$$\eta_Q = \eta_{QE}+\eta_P\eta_{QP}. \qquad \dots \quad (2.7)$$

The partial elasticities are estimated by the method of weighted regression in spite of known limitations of that approach, and the estimates are examined in the light of (2.7) in the following section.

3. SOME EMPIRICAL RESULTS

In estimating the different elasticities mentioned in Section 2 use has been made of a set of data relating to household expenditure collected from about 3,000 sample households in rural and urban areas of India in the 10th round of the National Sample Survey (December 1955-May 1956).* Among other details these data provide for each expenditure class i $(i = 1, 2, \dots, 12)$ w_i, $\overline{E}_i$, $\overline{V}_i$ and $\overline{Q}_i$. These variables are in monthly per capita terms. In the present study the following composite items have been considered by way of illustration : (i) *cereals* including rice, wheat, jowar, bajra, maize, barley, small millets, ragi, Bengal gram, and their products; (ii) *food grains* including cereals and substitutes for cereals like topioca etc; (iii) *sugar* including sugar, gur (cane and others), sugar candy and others; (iv) *salt* including sea salt, rock and other salts; (v) *milk* including cow milk, buffalo milk, goat milk and other forms of liquid milk.

Most of these data have been taken from published sources (Mahalanobis, 1958, 1959) except the quantity figures the latter being extracted from the tabulation prints available at the Indian Statistical Institute. Using the above data, cumulative proportions are first computed as under ;

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*For definition, scope and design of the survey the reader may consult the National Sample Survey Report No. 47 on Consumer Expenditure issued by the Cabinet Secretariat, Government of India, 1961.

$$\left.\begin{aligned} W_i &= \sum_{j=1}^{i} w_j \\ W_i^E &= \sum_{j=1}^{i} w_j\overline{E}_j \Big/ \sum_{j=1}^{12} w_j\overline{E}_j \\ W_i^V &= \sum_{j=1}^{i} w_j\overline{V}_j \Big/ \sum_{j=1}^{12} w_j\overline{V}_j \\ W_i^Q &= \sum_{j=1}^{i} w_j\overline{Q}_j \Big/ \sum_{j=1}^{12} w_j\overline{Q}_j \\ W_i^P &= \sum_{j=1}^{i} w_j\overline{P}_j \Big/ \sum_{j=1}^{12} w_j\overline{P}_j \\ (i &= 1, 2, 3, \ldots, 12) \end{aligned}\right\} \qquad \ldots \quad (3.1)$$

The points $\{W_i,\ W_i^E\}$ give the Lorenz curve of total expenditure while the other sets of points $\{W_i,\ W_i^V\}$, $\{W_i,\ W_i^Q\}$ and $\{W_i,\ W_i^P\}$ give respectively the specific concentration curves for value, quantity and price of the commodity. What is needed for purposes of estimation of the elasticities is not the entire curve in each case but a single point on the curve which corresponds to the median value of E, that is, the ordinate of the curve that corresponds to $W = 0.5$ (middle of the horizontal axis). These ordinates may be approximately obtained by simple interpolation between consecutive values of W which include $W = 0.5$. If such ordinates are denoted by W^{E*}, W^{V*}, W^{Q*} and W^{P*}, and their standard normal deviates by $t(W^{E*})$, $t(W^{V*})$, $t(W^{Q*})$ and $t(W^{P*})$ respectively, then the value, quantity and price elasticities are given by

$$\eta_V = \frac{t(W^{V*})}{t(W^{E*})};\ \eta_Q = \frac{t(W^{Q*})}{t(W^{E*})};\ \eta_P = \frac{t(W^{P*})}{t(W^{E*})}. \qquad \ldots \quad (3.2)$$

The following table gives the important stages of computation.

TABLE 1. QUANTITY, VALUE AND QUALITY ELASTICITIES FOR SELECTED GROUPS OF COMMODITIES

description of magnitudes	rural					urban					
	cereals	food grains	sugar	salt	all expenditures	cereals	food grains	sugar	salt	milk	all expenditures
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1. WE^*	–	–	–	–	0.2628	–	–	–	–	–	0.2570
2. WV^*	0.3579	0.3587	0.2004	0.4259	–	0.4159	0.4179	0.2530	0.4174	0.1771	–
3. WQ^*	0.3698	0.3724	0.2255	0.4380	–	0.4676	0.4688	0.2939	0.4342	0.2160	–
4. WP^*	0.4823	0.4799	0.4657	0.4877	–	0.4471	0.4482	0.4590	0.4831	0.4449	–
5. $t(WE^*)$	–	–	–	–	–0.6341	–	–	–	–	–	–0.6526
6. $t(WV^*)$	–0.3638	–0.3611	–0.8416	–0.1866	–	–0.2121	–0.2070	–0.6651	–0.2096	–0.9269	–
7. $t(WQ^*)$	–0.3319	–0.3266	–0.7554	–0.1560	–	–0.0803	–0.0753	–0.5417	–0.1662	–0.7858	–
8. $t(WP^*)$	–0.0451	–0.0502	–0.0853	–0.0301	–	–0.1332	–0.1307	–0.1030	–0.0426	–0.1383	–
9. η_V	0.5737	0.5695	1.3272	0.2943	–	0.3250	0.3172	1.0192	0.3212	1.4203	–
10. η_Q	0.5234	0.5151	1.1913	0.2460	–	0.1230	0.1154	0.8301	0.2547	1.2041	–
11. η_P	0.0711	0.0793	0.1345	0.0475	–	0.2041	0.2003	0.1578	0.0653	0.2119	–
12. $\eta_V - \eta_Q$	0.0503	0.0544	0.1359	0.0483	–	0.2020	0.2018	0.1891	0.0665	0.2162	–

The last two rows of Table 1 are roughly of the same magnitude. It would appear therefore that the method of concentration curves is reasonably consistent in the sense of equation (3.1). From these figures one may draw some broad conclusions. In the first place, the quantity and value elasticities in rural areas are for almost all items except salt higher than the corresponding figures in urban areas. For example, sugar appears somewhat to be a luxury for the rural population and this is perhaps not true to the same extent in urban areas. The commodities sugar and milk are in the nature of luxuries with their elasticities exceeding unity and the rest belong to the necessary group.

The last two rows which are approximately of the same order exhibit positive signs for quality elasticities for all the commodities irrespective of the regional differences. This would suggest that the consumers are generally tempted to pay higher prices for ostensibly similar items, that is, to move for better qualities within the commodity group as their standard of living improves. The degree of quality consciousness seems to be generally higher in urban areas. Moreover, relative luxuries such as sugar or milk are associated with higher values of quality elasticity. The present analysis seems to confirm the general notion that in rural areas of India the consumption habits are relatively more rigid than in urban parts.

The partial elasticities η_{QE} and η_{QP} for each of the selected items are estimated by the method of weighted least squares by using the National Sample Survey materials and these are given in Table 2. Estimates of quantity and quality elasticities, obtained by the method of concentration curves, are also given so that it is easy to verify the relationship (2.7) which connects the quantity and quality elasticities with the partial elasticities.

TABLE 2. QUANTITY AND QUALITY ELASTICITIES FOR EACH OF THE SELECTED ITEMS

description of the parameters	rural				urban				
	cereals	food-grains	sugar	salt	cereals	food-grains	sugar	salt	milk
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
η_{QE}	0.5721	0.5826	1.3309	0.2540	0.2341	0.1893	1.2322	0.2443	1.6538
η_{QP}	−0.7457	−0.8706	−0.5263	−0.7093	−0.5242	−0.3325	−1.9702	−0.1140	−1.8807
η_P	0.0711	0.0793	0.1345	0.0475	0.2041	0.2003	0.1578	0.0653	0.2119
$\eta_{QE}+\eta_{PQ}\,\eta_P$	0.5191	0.5126	1.2601	0.2165	0.1271	0.1227	0.9213	0.2369	1.2553
η_Q	0.5234	0.5151	1.1913	0.2460	0.1230	0.1154	0.8301	0.2547	1.2041

The last two rows are approximately of the same order suggesting thereby that the method of concentration curves is fairly consistent. It would also appear from the first two rows that the changes in physical demand are mostly explained by changes in the level of living i.e. per capita total expenditure whereas quality considerations are of minor importance. The negative sign of η_{GP} probability indicates that households within a given per capita expenditure group would prefer to buy smaller quantities of goods when they are somewhat costly. This is in line with the interpretation of partial price elasticity of demand computed from time series data. The high values of partial price elasticities for sugar and milk in urban areas suggest that these commodities have relatively high degree of substitutability. There is also some suggestion that the rural population generally prefers coarser varieties of food grains at low prices.

4. CONCLUDING REMARKS

A few remarks may perhaps be made by way of conclusion. The method of concentration curves has been found quite useful for analysis of grouped size-distribution data like those of the National Sample Survey for which some of the underlying assumptions have been shown to be plausible. This technique is consistent* and probably simpler than the weighted least squares method especially when concentration curves have already been drawn for other reasons or when one has fractile-type of data (Mahalanobis, 1960). The conclusions drawn from the above present studies are rather preliminary in nature but are nonetheless encouraging in so far as they broadly substantiate some of the commonly held notions about the Indian consumption behaviour.

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* Consistency and other statistical properties of our estimates are discussed in a recent paper (Iyenger, 1963).

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FERTILITY DIFFERENTIAL WITH LEVEL OF LIVING AND ADJUSTMENT OF FERTILITY, BIRTH AND DEATH RATES

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SUMMARY. In the present study, an attempt has been made to determine the economic differential of fertility on the basis of National Sample Survey (NSS) data (seventh round, rural). A method has been devised to estimate the extent of under-reporting of births (and deaths) and adjusted values of fertility, birth and death rates have been obtained.

1. Introduction

1.1. The present investigation is based on the lines indicated by Professor P. C. Mahalanobis in his Foreword to the paper on 'Couple Fertility' by A. Das Gupta, R. K. Som, M. Majumdar and S. N. Mitra.[1] The points that highlighted in this paper were firstly that fertility (as measured by the average number of children born per couple) was negatively correlated with level of living (as measured by per capita monthly expenditure), and secondly that fertility had increased in more recent marriages. The two combined would seem to point to a decline in the average level of living in the period covered by the investigation — a conclusion which perhaps could not be accepted without further examination of the problem. A working hypothesis regarding the variation of fertility with level of living was proposed by Professor Mahalanobis in the said Foreword, according to which, with a gradual rise in the level of living, fertility should increase at first, reach a peak value at a critical level of living and decrease thereafter. An extension to this hypothesis was suggested by the senior author,[2] which envisaged the diminishing trend to be reversed at a certain higher level of living and a rationale to the whole hypothesis was also proposed in the said note. There was, of course, the question of choosing appropriate indexes for fertility and for level of living and as pointed out in the note referred to above, it was current fertility that could be appropriately associated with current level of living and not the average number of children born per couple which was an index of past fertility performance, influenced by the possibly varying levels of living experienced in course of the past married life. In the present study, where an attempt has been made to test the hypothesis mentioned above, the current events approach in fertility data has therefore been adopted and a general fertility rate (for married women in their reproductive period) has been taken from the record of live births in the one year reference period. As for a suitable index for level of living, several were proposed in the Foreword and in the note mentioned above, a new index was suggested to represent the economic security of a couple, on which its fertility performance could be reasonably expected to depend. In the absence of necessary data for calculating this index, which might perhaps be available at a future round of the NSS undertaking a suitable Assets Survey, the following indexes for level of living (of which the second, among others was suggested in the Foreword) have been compared with one another, viz., (1) per capita monthly expenditure, (2) inverse Engel ratio and (3) proportion of expenditure on luxury items in monthly food expenditure, and for reasons explained later, the third one has been chosen for the purposes of this investigation.

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[1] The National Sample Survey: Number 7: *Couple Fertility*, Department of Economic Affairs, Ministry of Finance, Government of India, December, 1955.

[2] A Note by P. B. Gupta submitted to the Director, Indian Statistical Institute, on 3 November, 1959.

2. General line of analysis

2.1. The data in the rural sector (NSS : Seventh round, excluding the supplementary data which provided demographic information only and no information about household expenditure) were subdivided into small ranges of level of living as far as practicable, zone by zone, and the fertility rates, standardised for age distribution and for differential fertility of married females in two broad age-groups 15-29 and 30-49, in the respective proportions obtaining in the zone itself, and also, corrected for under-reporting of births, were examined for the purpose of this study.

2.2. One issue that is unavoidably involved in the calculation of the fertility rates is the reporting errors in births. If the under-enumeration of young children in a census is a usual feature, it is reasonable to suppose that there may be substantial under-reporting of births made by the informants of the households. It has not been proposed here to call this Recall Lapse, a lapse of memory directly related to the duration elapsed since the occurrence of the event, but a lapse, which in addition to lapse of memory may include a variety of other things, such as mistaking an event actually occurring in the course of the preceding year as having taken place earlier and so excluding it from the information supplied or just missing an event on account of want of mental alertness or of sense of responsibility, in short, a general lapse causing an overall under-reporting which should be inversely related to the educational standard or the mental acumen or ability of the informant. To test this point, the data have been subdivided, zone by zone in two broad educational standards of the informant :[3] (i) illiterate (code 0) and (ii) literate (code 1 and above) and the fertility rates calculated for both and standardised as mentioned above. It has been found that in each range of level of living as also in the whole range, level of living is highly correlated with educational standard of the informant and it has been assumed in this investigation that any fertility differential with educational standard is really that with the level of living associated with the educational standard. After having estimated the difference in the rates for the illiterate and literate groups as could arise out of the difference in the respective levels of living of those groups, a residual difference emerges, which could be attributed only to the differential under-reporting of births in these groups (fertility being assumed to be uncontrolled in rural areas, irrespective of literacy) or if the literate group be supposed to be free from this error, the difference is solely due to the under-reporting or response error made by the illiterate group.

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[3] According to the definition used in National Sample Survey, seventh round, code for educational standard (general education) : illiterate—0 ; literate but below primary—1, primary—2 ; middle—3 and so on.

2.3. A method has been devised, supported by mathematical theory, by which from purely internal evidence the coefficient of response error (as a percentage deduction from actual births to produce observed births in the illiterate group) and hence the corrected values of the fertility rates at different levels of living may be obtained. This not only sets out fertility differentials with level of living in a more pronounced manner but also provides an estimate of the adjustment for under-reporting, to be made to obtain a more correct crude birth rate than is provided directly from the data. If again it is assumed that reporting of deaths is in the first instance subject to the same error an assumption which seems to be justified from general considerations, then, quite apart from other errors in death records which may need further adjustments, we have a method of obtaining at least a preliminary adjustment for the crude death rate as well.

2.4. One of our objects in the present study is to assess an error (due to under-reporting of births) inherent in the information collected. A difference between the sub-sample estimates of the general fertility rate or the birth rate will of course be subject to sampling errors and also to non-sampling errors such as may be ascribable to the personal equations of different field investigators or to variations with time within the survey period and the like, but will not reveal the error referred to above or for that matter, any error inherent in the survey itself, as both sub-samples are equally affected by the incidence of the error concerned. Sometimes, however, (as in the present case), we have a method for estimating the error in each sub-sample separately and if the estimates from the sub-samples come out to be similar in magnitude and direction, this would strengthen the validity of the estimates and would justify combination of the sub-samples to produce a more precise estimate. Unfortunately, on account of the subdivisions adopted for applying the method, resulting in extreme paucity of data in each subdivision in an individual sub-sample, it is not worthwhile to work in sub-samples, in view of the possible emergence of results which would mask the extent or the existence of the error sought to be derived from each sub-sample. Accordingly, and especially as the present study is primarily one of methodology, the sub-samples were combined to produce an estimate of the response error, which derived as it was from a larger sample, would be looked upon with greater confidence. It would, however, be possible to obtain consistent results in sub-samples if the data from the different zones could be combined, but unfortunately, such a combination (apart from the zonal differentials in fertility) would be misleading for two reasons. Firstly, although the fertility pattern is about the same in the different zones, the turning point in the fertility curve does not occur at the same level of living in each zone, and secondly, the amount of response error is different in different zones. Each zone has its own characteristic and has, therefore, been studied by itself. The procedure that seems necessary in order to produce zonal estimates (or All-India estimates) in sub-samples is to combine the data of several consecutive rounds of the NSS on the justifiable assumption that fertility does not vary appreciably within a short period. Such a combination would enable us to examine the variation of fertility in greater detail instead of in broad outlines and might also yield age-specific rates and reproduction rates, and a series of such combinations would also make it possible to discover the trend, if any, in the fertility of the Indian population in successive periods of time. The combination of rounds would also yield a more reliable estimate of the response error as the literate group may then be taken to belong to a higher minimum educational standard, for which the response error may be assumed to be nil with greater certainty. In the present investigation, it was not possible to segregate a group with a higher minimum standard than code (1) (except in East Zone where the minimum is code (2)) as this would make the group too small.

2.5. It would thus appear that the present investigation is more or less one of study of methodology. It is believed that the methods employed here would yield reliable results confirmed by agreement between sub-sample estimates if applied to wider data as mentioned above. The investigation has been carried out on unweighted data throughout but it is believed that as the samples are self weighted with a limited number of inflation factors for purposes of estimation, the estimated values so obtained will not have differed materially from those observed from unweighted data. No claim is, however, made for the acceptance of the numerical values of the results obtained here, although attention will be drawn to their agreement with those obtained from other sources, but it is hoped that they are nevertheless fairly indicative of the true position in this country in respect of the issues dealt with in this investigation.

3. ECONOMIC DIFFERENTIAL OF FERTILITY : WORKING HYPOTHESIS AND ITS RATIONALE[4]

3.1. The practice of birth control or family planning may be supposed to be absent in rural India and the fertility performance of the rural population of India is, therefore, free from the artificial controls as these are known at present. Whatever restraints there are, may then primarily be of a psychological nature, caused by economic reasons. In other words, the economic status of parents (which for the moment may be taken to mean standard of living) is a factor with which their reproductive activity or the general fertility rate of the wives in their reproductive period may be usefully associated. The working hypothesis adopted for this study is that with increasing standard of living, the fertility rate should rise to a maximum, fall to a minimum and again rise and tend to attain an optimum value. A rationale to this hypothesis is suggested, as follows.

3.2. At a very low level of living, say for almost destitute couples, the fertility rate must be small as the reproductive forces have to be kept under considerable restraint in the prevailing unfavourable circumstances. With an increase in standard of living, the forces are released resulting in an increase in the fertility rate. It is possible that this increase is assisted by the greater vitality of married women caused by a higher living standard, if fecundity depends on vitality. But the fertility performance may be supposed to be subject primarily to two psycho-economic factors, viz., (i) the need for raising or maintaining the standard of living tending to restrict the family size and (ii) economic gain in producing further children. At comparatively lower living standards, (i) is small, while (ii) is large, as more children produced will commence earning and adding to the family income at early ages, without the parents having to spend much for their upbringing or their subsequent maintenance. This results in increased fertility but as the level of living goes on increasing, factor (i) gains and factor (ii) loses for obvious reasons, with the result that the fertility rate attains a peak value and then begins to fall. The fall, however, cannot proceed below a certain minimum value of fertility. Factor (ii) had of course been fast losing its significance while (i) must be slowing down as a motive force as the standard of living continues to rise. In fact, it should tend to a vanishing point, so that under the comparatively free display of the forces of reproduction, fertility will commence to rise and rise gradually to an optimum value corresponding to the fullest capacity of reproduction of a married couple.

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[4] From the note submitted to the Director, Indian Statistical Institute by P. B. Gupta on 3 November, 1959.

3.3. A suggestion may be made about the choice of a suitable index for the economic status of parents, which has so far been taken to mean their standard of living. Human reproduction is necessarily linked up with a long-run question of upbringing of the children born. The economic status should also for the same reason have a long-term aspect, envisaging the future as well as taking the present into account. It should be, in other words, economic security, which need not be determined by the per capita monthly income or expenditure alone, nor by the standard of living as measured by the inverse Engel ratio or alternative indexes. It seems that in assessing economic security, not only current income but capital resources also have to be taken into account. One way of doing this would be to capitalise the income per annum earned or to be earned by labour or work only during the working period of an individual's life at an appropriate rate of interest and mortality, and to add to the capitalised income, the present value of the capital assets possessed, some of which may not be directly or immediately producing any income at present. The total will then be an index of economic security on which the fertility rate may be more appropriately expected to depend.

4. ON THE CHOICE OF AN INDEX FOR LEVEL OF LIVING

4.1. As stated before, three different indexes for level of living of a household were selected for mutual comparisons : (i) per capita monthly expenditure in rupees (PCME), (ii) the ratio of the total monthly expenditure to the expenditure on food only or the inverse Engel ratio (IER), expressed as a percentage and (iii) the proportion of expenditure on luxury items[5] in monthly food expenditure (PLIF), expressed as a percentage. To test which of these indexes would be the most suitable, use has been made of the well-known principle that the infant mortality rate and the infant death proportion are both good indices of the standard of living of the family or household to which the infants belong. A newly born child has not yet developed resistance to adverse conditions, so that mortality in the first year of life is determined to a large extent by environment, which is adverse or favourable as the standard of living is low or high. From the data grouped in the first instance, into suitable ranges of living, according to each of the indexes the median level of living was found and the data (births and infant deaths) were grouped under lower (below median) and higher (median and above) levels of living according to each index and in each zone. The infant death proportion (IDP) (proportion of infants born alive and dying in the reference period of one year) and the infant mortality rate (IMR) (the ratio of infants dying in the first year of life during the reference period to the live births in the reference period) were calculated for lower and higher levels of living according to each index, all zones being taken together as the data for individual zones are small.

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[5] Luxury items include milk and milk-products, fruits and nuts, meat, fish, eggs, beverage and refreshments.

TABLE 1. INDEXES SHOWING IDP AND IMR IN LOWER AND HIGHER LEVELS OF LIVING : (ALL ZONES COMBINED) NATIONAL SAMPLE SURVEY : SEVENTH ROUND, RURAL

	PCME		IER		PLIF		combined
	level of living		level of living		level of living		
	lower	higher	lower	higher	lower	higher	
number of live births	435	339	357	417	347	427	774
number of births code (2)[a]	36	50	40	46	41	45	86
θ_0[b]	47	69	54	62	53	63	116
IDP	.083	.147	.112	.110	.118	.105	.111
IMR	.108	.204	.151	.149	.153	.148	.150
					IDP/IMR=.74 (combined)[c]		

[a] Born alive and dying during the reference period.

[b] Deaths at age 0 last birthday during the reference period.

[c] cf. 70.5% derived by the Census Actuary for 9 states combined (Census of India, Paper No. 6, 1954).

4.2. Table 1 shows that by per capita monthly expenditure, both IDP and IMR are substantially higher at the higher level of living, which makes per capita monthly expenditure inadmissible as a suitable index for level of living. Comparing the other two indexes, with both of them IMR and IDP are both lower at the higher standard of living but whereas the decrease in the values from lower to higher standard are 1.3% and 1.8% respectively with IER, they are 3.3% and 11.0% respectively with PLIF. In the present investigation, therefore, the PLIF has been chosen as the most suitable index for level of living. It may be noted that the values of IDP and IMR as shown above are practically free from response error as the numerator and denominator of each are both subject to the said error presumably to nearly equal extents, on the basis of the theory of response error applying equally to reported births and deaths (Section 2.3 and Section 5.9(a)(iv)).

4.3. It may, however, be argued that although the extent of under-reporting of total deaths at all ages may be approximately the same as that of live births, the deaths under age 1 year may need special consideration. We have $\text{IMR} = \frac{{}^{-1}D_0+{}^{0}D_0}{S_0+{}^{0}D_0}$, where ${}^{0}D_0$, ${}^{-1}D_0$ are deaths in the first year of life out of live births in the reference year and in the previous year respectively and $S_0 =$ live births in the reference year surviving to the end of the year. Now the incidence of under-reporting is likely to fall more heavily on ${}^{0}D_0$ than on S_0 which is much larger than ${}^{0}D_0$, or on ${}^{-1}D_0$ which is much smaller than ${}^{0}D_0$. The extent of under-reporting in the numerator of IMR should, therefore, be greater than in the denominator and the observed IMR less than the true IMR. Further, the differential in this respect according to level of living has also to be considered.

Making certain reasonable assumptions as to the extent of under-reporting of the various components of the numerator and denominator of IMR, at both lower and higher levels of living, we find that the rejection of per capita monthly expenditure as an index is still justified and the grounds for adoption of PLIF as a more satisfactory index are strengthened.

4.4. The per capita monthly expenditure has a traditional position, having been used by many research workers in the past as an index for level of living. But it has also been recognised that a large number of children itself tends to lower the per capita monthly expenditure and to show an apparent decline in the level of living. An additional and important point is that it fails to take into account the influence of the size of the household on the total monthly expenditure. Taking two families enjoying the same standard of living, the size of one being, say, double that of the other, many items in monthly expenditure are obviously not doubled in the family of the larger size, and in consequence, the per capita monthly expenditure comes out to be of a lower value than that in the family of the smaller size, although both the families are at the same standard of living. In general, then, by taking per capita monthly expenditure as the index for a level of living, the larger families tend to be grouped at a lower and similarly, smaller families at higher levels of living than they are respectively enjoying. The IER can be expected to be more or less free from this defect but it is debatable whether the monthly food expenditure and total monthly expenditure would increase in the same proportion when the family size is increased. It would appear that PLIF might be the best one in this regard, because it is reasonable to assume that if the monthly food expenditure increases in a certain proportion with the rise in family size the expenditure on the luxury items in food is expected to rise also in the same proportion at a given standard of living.

4.5. If the rise (fall) in IMR from the lower range of level of living to the higher range, with PCME (PLIF) as index for level of living, is supposed to be linear, it would point to the existence of negative correlation between the two indexes, whereas the correlation is actually found to be positive. The anomaly is only apparent, because in the first place, it would not be safe, from only a pair of grouped values, to conclude about the nature of the underlying curve or to say that the variation is linear. Secondly, as shown below, the defect in PCME as outlined in the preceding section may well produce the abnormal behaviour of IMR when this is taken as the index for level of living.

Assuming that this defect is corrected, the corrected PCME will be similar to PLIF (assumed correct by itself) and IMR would show a continuous fall with a rise in the value of the index. If the curve is divided into two parts by the median value, the group rate in the higher range will of course be lower. From Table 1 figures for live births (infant deaths) in the two ranges show a net transference from higher (lower) to lower (higher) range, when PLIF (corrected PCME) is substituted by PCME. It appears, therefore, that with the usual PCME as index, some (larger on the average) households of an actually higher level of living and at a lower IMR are transferred to a lower level, diminishing the IMR at that level and some (smaller on the average) households of an actually lower level of living and at a higher IMR are transferred to a higher level, increasing the IMR at that level. The earlier part of the IMR curve will, therefore, tend to be depressed and the latter part to be elevated, which might cause the group rate in the lower range to be smaller than at the higher range, although on the whole, IMR could still show a fall from low to high level of living. As only some households at higher PLIF are transferred to lower PCME and vice versa, the correlation (which should be high between PLIF and corrected PCME) would diminish but could at the same time remain positive (between PLIF and PCME), as is actually the case.

The above reasoning is supported by the results in the table below, which has been obtained by analysing the households transferred from PLIF (lower range) to PCME (higher range) and vice versa in respect of their number and average size, and

TABLE 2. ANALYSIS OF TRANSFERRED HOUSEHOLDS

zone (number of households)	transference from lower PLIF to higher PCME						transference from higher PLIF to lower PCME					
	number of households	total population	live births				number of households	total population	live births			
			code (3)	code (2)	total	θ_0			code (3)	code (2)	total	θ_0
East (1050)	153	681 (4.5)	20	2	22	2	151	852 (5.6)	39	2	41	3
North (694)	107	427 (4.0)	9	6	15	7	112	710 (6.3)	34	0	34	0
North West (479)	74	327 (4.4)	13	5	18	5	72	479 (6.7)	17	2	19	2
West (549)	84	377 (4.5)	8	1	9	1	94	535 (5.7)	27	4	31	5
Central (659)	100	371 (3.7)	17	2	19	3	116	635 (5.5)	33	1	34	2
South (694)	111	432 (3.9)	9	0	9	2	133	770 (5.8)	19	2	21	2
all zones combined (4125)	— 629	2615 (4.2)	76	16*	92	20*	677	3981 (5.9)	169	11*	180	14*

*IDP—16/92
IMR—20/92

*IDP—11/180
IMR—14/180

Note : Figures in brackets denote average size of households.

of the live births and infant deaths occurring in them. The figures are given for separate zones and also for all zones combined.

The following points arising out of the above table may be noted :

(i) The transferences either way should be theoretically equal in number but the discrepancy is probably due to the approximate calculation of the medians on the assumption of uniform distribution in the ranges that had to be split up.

(ii) The average size of households transferred from higher PLIF to lower PCME is systematically greater than that of those transferred from lower PLIF to higher PCME in all the zones by about 2, which points to the defect of PCME already discussed.

(iii) Considering all-India figures, IDP and IMR are substantially lower in the households transferred from higher PLIF to lower PCME than in the households transferred from lower PLIF to higher PCME, which would distort the curve in the manner discussed above.

(iv) As for the group rates, the result of the net transferrence is that with PCME as compared to PLIF (lower range), the number of live births is increased by 88, while the number of deaths (code (2)) and θ_0 are diminished by 5 and 6 respectively, and the reverse movements of equal amounts take place with PCME as compared to PLIF (higher range). This makes the group rate at the higher range of PCME considerably higher than the group rate at the lower range, a result opposite to that obtained with PLIF.

From Tables 1 and 2 the following table may be constructed.

TABLE 3. INFANT MORTALITY RATE BY PCME AND PLIF

PCME	PLIF lower	PLIF higher	PLIF combined
lower	.129 (255)	.078 (180)	.108 (435)
higher	.217 (92)	.198 (247)	.204 (339)
combined	.152 (347)	.147 (427)	.150 (774)

Figures in brackets denote the number exposed to risk.

χ^2 tests on the data given in Table 3 reveal that whereas the increase in IMR from low PCME to high PCME (whether in low or high PLIF groups or both groups combined) is statistically significant, the decrease in IMR from low PLIF to high PLIF (whether in low or high PCME groups or both groups combined) is not so. This supplies the statistical basis for rejection of PCME as a suitable index, in confirmation of the general basis of a high percentage increase as a ground for rejection. At the same time PLIF is not entirely satisfactory as it fails to produce a significant decrease from low to high level of living. This may be due to paucity of data, but in any case PLIF is an improvement on PCME, in not producing an anomalous behaviour of IMR in the way the latter does.

4.6. There is a further point that per capita monthly expenditure in successive period of time would not show the trend of the standard of living unless adjusted for the variation, if any, of the general price level during the periods. The inverse Engel ratio or the proportion of expenditure on luxury items in food expenditure would appear to be more or less free from this defect.

5. FERTILITY DIFFERENTIAL WITH LEVEL OF LIVING—ADJUSTMENT OF FERTILITY RATES AND OF THE CRUDE BIRTH AND DEATH RATES FOR RESPONSE ERROR

5.1. As already indicated, the fertility index has been taken to be the general fertility rate for married women in the reproductive period, from age 15 to age 49. This eliminates the variation in proportion married from zone to zone, which would have to be taken into account if the index were the general fertility rate for all women. The proportion married is of course high and does not vary much from zone to zone, but it is better to work on the basis of married women in the first instance and, if necessary, to arrive at the rates for all women by applying the appropriate factors for the various zones. It will be noted that the investigation refers only to legitimate fertility, but fertility in India is almost invariably legitimate and, in any case, NSS data do not yield information as to births, if any, outside lawful wedlock.

5.2. The rural data of each zone are subdivided as far as practicable into small ranges of level of living, which have been so chosen that the data in the different ranges may be relatively adequate and the turning points in the curves may be brought out as clearly as possible. The fertility rate in a given range is approximately applicable to the average level of living of the range, calculated from $\frac{\Sigma E_x \, . \, x}{\Sigma E_x}$ where $E_x =$ the number of married women (15-49) at the level of living x. Fertility in the age group 15-29 in each range has been found to be substantially higher than in the age group 30-49 and so the fertility rate in the age-group (15-49) at each average level of living has been standardized with reference to the ratio of these rates as in the whole range and to the proportions of married women in the two age-groups as in the whole data. No attempt has been made to standardize in respect of variation of duration since marriage, because rural marriages in India take place mostly either before or quite early after attainment of puberty of the bride so that any substantial variation in duration since marriage (counted from not earlier than age 15) is not supposed to exist among married women in a particular age-group. In any case the records of the duration in the NSS data are unsatisfactory being given in too broad groups. It is suggested that duration be better recorded in completed years since marriage as recorded in the case of mothers at child-birth.

5.3. The whole data are again subdivided in another way, viz. according to the educational standard of the informant, the educational standard (0) and educational standard (1) and above forming the illiterate and literate groups respectively (except in East zone, where the data being more plenty, the educational standard (2) and above form the literate groups). The informant is in most cases the head of the household and it is assumed that the educational standard of the whole household (including the married women and their husbands) is given by that of the informant. The fertility rates for the two groups mentioned above are obtained and standardized in the same way as before and the average level of living calculated as described already. These standardized group rates together with the standardized rates at different levels of living provide the basis for the calculation of the coefficient of response error mentioned in Section 2. In the following paragraphs the theory of the method is given where standardized true rates are always meant though not specifically mentioned.

5.4. If $I_x =$ general fertility rate (married women) at level of living x, $E_x dx =$ number of married women (15-49) between level of living (x to $x+dx$). ${}_nI_0 =$ group fertility rate between $x = 0$ and $x = n = I_{(1)}$ (say)

then $${}_nI_0 = I_{(1)} = \frac{\int_0^n E_x I_x dx}{\int_0^n E_x dx} = \int_0^n f_x I_x dx \text{ where } f_x dx = \frac{E_x dx}{\int_0^n E_x dx}$$ = proportion of married women between level of living (x to $x+dx$) to the total number of married women between $x = 0$ to $x = n$.

If I_x is a linear function of x i.e. $I_x = A+Bx$,

then
$$I_{(1)} = \int_0^n f_x(A+Bx)\,dx$$
$$= A+B\int_0^n x f_x dx \qquad \left[\because \int_0^n f_x dx = 1\right]$$
$$= A+Bt \text{ (where } t = \int_0^n x f_x dx = \text{average level of living of the group, } x = 0 \text{ to } x = n)$$
$$= I_t$$

Thus t is the value of the variable to which the group rate $I_{(1)}$ applies. In any other case, when I_x is not a linear function of x, the above does not hold, in other words, the value of the variable to which the group rate corresponds differs from the average value of the variable t. If now the curve can be represented by an equation of the second degree (see later for justification of this assumption), $I_x = A+Bx+Cx^2$.

Then
$$I_{(1)} = \int_0^n f_x(A+Bx+Cx^2)dx$$
$$= A+Bt+C\int_0^n x^2 f_x dx.$$

If now the above refers to grouping according to educational standard (1) and above, i.e. to the literate group, then similarly for grouping according to educational standard (0) i.e. for the illiterate group between the same limits $x = 0$ to $x = n$.

we have

$$I_{(0)} = A+Bt'+C\int_0^n x^2 f'_x dx$$

$$\therefore\ I_{(1)}-I_{(0)} = B(t-t')+C\int_0^n x^2(f_x-f'_x)dx \qquad \ldots \quad (5.1)$$

Again,

$$I_t-I_{t'} = B(t-t')+C(t^2-t'^2) \qquad \ldots \quad (5.2)$$

$$[I_{(1)}-I_{(0)}]-[I_t-I_{t'}] = C\left[\left(\int_0^n x^2 f_x dx\right)-t^2\right]-C\left[\left(\int_0^n x^2 f'_x dx\right)-t'^2\right]=C(\sigma^2-\sigma'^2)$$

where σ and σ' are the respective standard deviations of the two distributions. Now from the general nature of the two distributions, the standard deviations are not expected to differ much from one another and further C is a very small coefficient (vide Appendix A).

Hence

$$I_{(1)}-I_{(0)} \simeq I_t-I_{t'} \qquad \ldots \quad (5.3)$$

i.e., the difference between the group rates should approximately be the same as the difference between the individual rates at the average levels of living of the groups.

5.5. The observed value of $(I_{(1)}-I_{(0)})$ is however found to differ substantially from the observed value of $(I_t-I_{t'})$ in each of the zones. This is due to the above rates having been affected by under-reporting of births and that too, by unequal extents on the hypothesis (as explained in Section 2) that the under-reporting in the literate group must be less than that in the illiterate group. In other words, if the observed rates could be corrected for this error, the equality between $(I_{(1)}-I_{(0)})$ and $(I_t-I_{t'})$ would hold good. The method adopted for correcting this error is given below.

5.6. If B' = observed number of births and B = actual number of births, then $B' = B(1-l)$ or $l = \frac{B-B'}{B}$, where l is a proper fraction and is defined as the coefficient of Response Error (cf. coefficient of expansion in Physics), so that $l\times 100$ = percentage deduction to be made from actual births to obtain the observed births.

Further, l_0 and l_1 are the coefficients applicable to groups at educational standards (0) and (1) and above, respectively. It follows that denoting the observed values of $I_{(1)}$ and $I_{(0)}$ by $I'_{(1)}$ and $I'_{(0)}$ respectively,

$$I_{(1)} = \frac{I'_{(1)}}{1-l_1},\ I_{(0)} = \frac{I'_{(0)}}{1-l_0}. \qquad \ldots \quad (5.4)$$

Now turning to the individual rate I_x, both coefficients l_0 and l_1 are in operation and to extents depending on the proportions of married women belonging to educational standards (0) and (1) and above respectively, at the level of living x. If p_x and q_x be these proportions respectively ($p_x+q_x = 1$) we have the observed rate

$$I'_x = I_x[p_x(1-l_0)+q_x(1-l_1)],$$

where I_x = corrected rate so that

$$I_x = \frac{I'_x}{1-p_x l_0 - q_x l_1} \cdot \qquad \ldots \quad (5.5)$$

If now t falls between a and b i.e. two values of x, at which I'_x is known from the data,

then
$$I_a = \frac{I'_a}{1-p_a l_0 - q_a l_1}$$

$$I_b = \frac{I'_b}{1-p_b l_0 - q_b l_1} \quad \text{(from equation 5.5)}$$

and by linear interpolation I_t can be expressed in terms of I_a and I_b. Similarly $I_{t'}$ can be expressed in terms of I_c and I_d (where t' falls between $x=c$ and $x = d$). Using I_t and $I_{t'}$ as found above in conjunction with (5.3), (5.3) reduces to an equation where all the quantities involved except l_0 and l_1 are known and neglecting higher powers than the second, it can be shown that l_0 is substantially greater than l_1 (vide Appendix A). If the literate group be assumed to be free from response error, i.e. if $l_1 = 0$, l_0 is obtained from the above equation.

5.7. We have seen how to correct values of $I'_{(1)}$ and $I'_{(0)}$ for under-reporting (5.4). The formula for correcting the value of the group rate for all educational standards combined, $I'_{(c)}$, say, can be obtained as follows:

If the proportion of married women at level of living x to the total of married women at all levels $= \pi_x$

$$(\sum_x \pi_x = 1).$$

Then
$$\begin{aligned} I'_{(c)} &= \Sigma[\pi_x p_x I_x(1-l_0)+\pi_x q_x I_x(1-l_1)] = \Sigma\, \pi_x I_x(1-p_x l_0 - q_x l_1) \\ &= (1-\bar{p}' l_0 - \bar{q}' l_1)\, \Sigma \pi_x I_x, \quad (p_x \text{ and } q_x \text{ being already defined}) \end{aligned}$$

where
$$\bar{p}' = \frac{\Sigma\, \pi_x I_x p_x}{\Sigma\, \pi_x I_x} \text{ and } \bar{q}' = 1-\bar{p}'.$$

If now
$$\bar{p} = \frac{\Sigma\, \pi_x p_x}{\Sigma \pi_x} \text{ and } \bar{q} = 1-\bar{p}.$$

we have approximately, (replacing $\bar{p}'$ and $\bar{q}'$ by $\bar{p}$ and $\bar{q}$ respectively)

$$I'_{(c)} = (1-\bar{p} l_0 - \bar{q} l_1) \Sigma\, \pi_x I_x = (1-\bar{p} l_0 - \bar{q} l_1) I_{(c)}$$

where $I_{(c)}$ is the corrected rate.

$$\therefore \quad I_{(c)} = \frac{I'_{(c)}}{1-\bar{p} l_0 - \bar{q} l_1} = \frac{I'_{(c)}}{1-\bar{p} l_0} \qquad \ldots \quad (5.6)$$

if l_1 is assumed to be $= 0$, where $\bar{p}$ = proportion of married women at educational standard (0) in the whole data. This result is of importance as will be seen later.

5.8. We give below a summary of results for the zones (National Sample Survey : Seventh Round, Rural) :

TABLE 4. FERTILITY RATES ACCORDING TO LEVEL OF LIVING IN GROUPS

zone (l_o)	average level of living in group (PLIF%) x	standardised general fertility rate (married women) I'_x	percentage of married women at lower educational standard $100p_x$	standardised general fertility rate (married women) corrected for response error I_x	number of married women E_x	$I_{(c)} = \frac{\Sigma(5)\times(6)}{\Sigma(6)}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)
East (.188)	.6	.175	97	.214	195	.210
	3.3	.181	95	.220	171	
	7.6	.161	95	.196	238	
	12.3	.142	88	.170	178	
	23.0	.201	81	.237	296	
South (.164)	1.6	.142	80	.163	140	.168
	7.5	.150	75	.171	115	
	12.6	.178	69	.201	98	
	19.6	.141	51	.154	173	
	32.0	.157	33	.166	70	
North West (.142)	5.7	.157	83	.178	207	.230
	20.1	.259	70	.288	115	
	40.4	.225	71	.250	194	
Central (.027)	1.7	.168	89	.172	226	.218
	9.7	.249	78	.254	201	
	18.7	.253	65	.257	104	
	32.8	.207	50	.210	97	
West (.022)	5.0	.160	85	.163	209	.185
	12.3	.219	72	.222	94	
	17.5	.195	62	.198	81	
	30.0	.184	53	.186	208	
North (.046)	1.6	.156	81	.162	276	.204
	7.5	.218	79	.226	106	
	12.2	.275	79	.285	102	
	20.1	.225	78	.233	125	
	34.1	.179	64	.184	139	

TABLE 5. FERTILITY RATES ACCORDING TO EDUCATIONAL STANDARD

zone (100p)	educational standard	average level of living (PLIF%)	standardised fertility rate (married women) I'	standardised fertility rate (married women) corrected for response error I	number of married women E	$I_{(c)} = \frac{\Sigma(5)\times(6)}{\Sigma(6)}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)
East (90)	0—1	9.9	.169	.208	974	
	2—	17.3	.225	.225	104	.210
	combined	10.7	.174	.209	1078	—
South (63)	0	10.9	.149	.178	378	
	1—	17.5	.154	.154	218	.169
	combined	13.4	.151	.168	596	—
North West (76)	0	20.9	.200	.233	392	
	1—	25.5	.224	.224	124	.231
	combined	22.0	.205	.230	516	—
Central (75)	0	9.5	.211	.217	474	.218
	1—	19.0	.221	.221	154	
	combined	11.9	.213	.217	628	
West (69)	0	14.3	.187	.191	408	
	1—	21.9	.172	.172	184	.185
	combined	16.7	.182	.185	592	—
North (77)	0	11.9	.200	.210	576	
	1—	16.3	.186	.186	172	.204
	combined	12.9	.197	.204	748	—

TABLE 6. $I_{(c)}$, STANDARDIZED GENERAL FERTILITY RATE FOR ZONE, CORRECTED FOR RESPONSE ERROR, BY DIFFERENT METHODS

zone	$\frac{\Sigma E_x I_x}{\Sigma E_x}$ column (7) of Table 4	$\frac{\Sigma EI}{\Sigma E}$ column (7) of Table 5	$\frac{I'_{(c)}}{1-pl_0}$ last value of column (5) of Table 5
	(1)	(2)	(3)
East	.210	.210	.209
South	.168	.169	.168
North West	.230	.231	.230
Central	.218	.218	.217
West	.185	.185	.185
North	.204	.204	.204

TABLE 7. CRUDE BIRTH AND DEATH RATES (PER 1000)

zone	crude birth rate		crude death rate	
	unadjusted	adjusted	unadjusted	adjusted
(1)	(2)	(3)	(4)	(5)
East	34.5	41.5	15.8	19.0
South	26.5	29.7	13.5	15.7
North West	39.9	44.8	15.1	17.2
Central	43.5	44.4	19.8	20.2
West	38.1	38.7	15.2	15.4
North	40.0	41.4	22.3	23.0

TABLE 8. GENERAL FERTILITY, BIRTH AND DEATH RATES ADJUSTED FOR RESPONSE ERROR ; AND FOR COMPARISON, FINAL ESTIMATES OF BIRTH AND DEATH RATES (1941-50, ALL-INDIA AND ALSO BY ZONES) : NATIONAL SAMPLE SURVEY SEVENTH ROUND, RURAL

zone	general fertility rate (married women)	crude birth rate	proportion of married women (15-49) in zonal population	crude death rate	i_1/i_2 [a]	100π [b]	final estimate (1941-50) taking central value of range suggested*	
							birth rate	death rate
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
East	.210	41.5	.198	19.0	1.49	60	38.5	27.0
South	.169	29.7	.176	15.7	2.20	50	36.5	21.5
North West	.230	44.8	.194	17.2	1.63	59	41.5	25.0
Central	.217	44.4	.204	20.2	1.65	60	44.0	34.0
West	.185	38.7	.209	15.4	2.04	55	42.0	26.0
North	.204	41.4	.203	23.0	1.18	59	38.5	27.5
all-India: rural	.203	40.0	.197	18.6		all India	40.0	27.0

*Census of India, Paper No. 6, 1954 (pp. 14-18).

[a] i_1 and i_2 are respectively the fertility rates in the age-groups (15-29) and (30-49).

[b] π is the proportion of married women in the age-group (15-29) out of the total of married women(15-49).

5.9. *Discussion and comparison of results of different zones* : (a) *comparison of fertility and other rates :*

(i) Although, it has not been possible to derive age-specific fertility rates in small age-groups, column (6) of Table 8 shows the comparative fertility in two broad age groups (15-29) and (30-49). The fertility in the former age-group is considerably higher, varying between 118% (North zone) to 220% (South zone) of that in the latter age-group. The answer to the question as to why there should be such large variations between the zones in respect of the comparative fertility of younger and older women may perhaps be sought for in the different ethnical characteristics of the zones.

(ii) It may be noticed that fertility of married women is lowest in the South zone but it is in this zone that the fertility differential between the age-groups (15-29) and (30-49) reaches its highest value, while the proportion of married women in the more fertile age-group (15-29) is lower than in other zones. Again, the birth rate in the South zone is the lowest and so also the proportion of married women in the zonal population. These considerations are relevant to a proper appraisal of the comparative fertility performance and birth rate of the different zones.

(iii) The growth rate (1941-50 : All-India) is 1.3% per annum whereas the estimate of the growth rate in this investigation (1953-54 : All-India Rural) is 2.14% per annum. It is noticeable that the birth rates are 40.0 in both cases, which on the assumption of the absence of a significant urban-rural differential in the fertility performances of the Indian population[6] perhaps shows that the birth rate had remained stationary for a few years after the last census, while the death rate has declined substantially.

(iv) For All-India (rural), the estimate of the omission from actual births (due to under-reporting) is 8.5%.

Similarly, the estimate of the omissions from actual deaths is 8.9%. These figures are close and similar must also be the figures for the individual zones. In this connection it is useful to consider the results of the Sample Census of births and deaths (1953-54) carried out by the Indian Census Authorities in Uttar Pradesh[7] where one of the purposes was to obtain for the State (as also for the districts) estimates of the true birth and death rates. From the survey of 1% of households in the rural areas of the State with a reference period taken to be the preceding one year, the rural birth and death rate for the State came out to be 26.4 and 16.6 respectively. The correct rates were, however, estimated to be respectively 38.8 and 24.0 so that the estimate of under-enumeration of births and deaths in the sample census was 32% and 31% respectively. Apart from the fact that the estimated true rates agree closely with the corresponding corrected values obtained from this investigation (41.4 and 23.0) the point to notice is the closeness of the estimates of under-enumeration of births and deaths. A similar feature is noticed in the results of the Mysore Population Study (1952), conducted under the joint auspices of the United Nations and the Government of India, where in connection with the examination of the validity of birth and death rates obtained from the data, the extents of the completeness of reporting of vital events by investigators in the household survey were studied, and the omissions from actual births and deaths (in the three rural zones combined) were estimated at 7% and 9% respectively.

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[6] *Couple Fertility* (*loc. cit.*).

[7] Census of India, Paper No. 1, 1955.

The almost similar magnitudes of the percentage omissions in the enumeration of births and deaths as mentioned above lend support to the theory of response error applied equally to birth and death statistics in this investigation.

TABLE 9. FERTILITY DIFFERENTIAL WITH LEVEL OF LIVING

zone	level of living (PLIF %)	corrected general fertility rate	variation from lowest to highest values (difference)	approximate* standard error of difference	difference in (4)/(5)	nature of variation with level of living
(1)	(2)	(3)	(4)	(5)	(6)	(7)
East	.6	.214	.170—.220 (.050) (29%)	.042	1.2	a small initial rise followed by a fall to a minimum and a subsequent rise
	3.3	.220				
	7.6	.196				
	12.3	.170				
	23.0	.237	.170—.237 (.067) (39%)	.039	1.7	
South	1.6	.163	.163—.201 (.038) (23%)	.050	0.8	a rise to a maximum, then a fall to a minimum and a small subsequent rise.
	7.5	.171				
	12.6	.201				
	19.6	.154				
	32.0	.166	.154—.201 (.047) (31%)	.048	1.0	
North West	5.7	.178	.178—.288 (.110) (62%)	.048	2.3	a rise to a maximum, and then a fall.
	20.1	.288				
	40.4	.250	.250—.288 (.038) (15%)	.052	0.7	
Central	1.7	.172	.172—.257 (.085) (49%)	.047	1.8	a rise to a maximum and then a fall.
	9.7	.254				
	18.7	.257				
	32.8	.210	.210—.257 (.047) (22%)	.060	0.8	
West	5.0	.163	.163—.222 (.059) (36%)	.048	1.2	a rise to a maximum and then a fall.
	12.3	.222				
	17.5	.198				
	30.0	.186	.186—.222 (.036) (19%)	.049	0.7	
North	1.6	.162	.162—.285 (.123) (76%)	.045	2.7	a rise to a maximum and then a fall.
	7.5	.226				
	12.2	.285				
	20.1	.233				
	34.1	.184	.184—.285 (.101) (54%)	.057	1.8	

*On the hypothesis that there is no fertility differential between the two levels of living.

(b) *Fertility differential with level of living.* The percentage variations in column (4) of Table 9 seem to be substantial but many of them are not statistically significant. This, of course, does not prove the absence of any fertility differential and is presumably due to paucity of data. Some of the variations are significant and also all the zones reveal a uniform pattern of rise and fall (ignoring for the present the subsequent rise in the East and South zones) which may not perhaps be dismissed as spurious. To establish however that such a pattern exists it is necessary to standardize the zonal rates for area and get them all together in the same scale and to see whether a curve showing a rise and fall could be fitted to them. Such a method is described below.

It is proposed as a hypothesis that a second degree curve (showing a rise and then a fall) underlies the rates for each zone and is given by the equation

$$y = a+bx-cx^2 \qquad \dots \quad (5.7)$$

where $y =$ fertility rate and $x =$ the index for level of living.

$$\therefore \quad \frac{dy}{dx} = b-2cx = 0 \qquad \text{(for maximum)}$$

$\therefore \; x_c = \frac{b}{2c}$, where $x_c =$ critical value of the level of living corresponding to y_m; the maximum value of y. Also,

$$y_m = a+bx_c-cx_c^2 = a+\frac{b^2}{4c}$$

and since y_0 (the value of y at $x = 0) = a$,

$$y_m-y_0 = \frac{b^2}{4c}.$$

With a new variable $x' = \frac{x}{x_c}$, $y-y_0 = bx-cx^2 = bx'\cdot x_c-cx'^2\cdot x_c^2 = \frac{b^2}{2c}\,x'-\frac{b^2}{4c}\,x'^2$

$$\therefore \quad \frac{y-y_0}{y_m-y_0} = 2x'-x'^2$$

or

$$y' = 2x'-x'^2 \qquad \dots \quad (5.8)$$

where

$$y' = \frac{y-y_0}{y_m-y_0},$$

a general equation applicable to the rates for each zone where with the above transformation of coordinates the constants a, b, c (different for different zones) have been eliminated.

By the method of successive summations applied to weighted data (ignoring those relating to a subsequent rise in rates in the East and South zones as mentioned above) the equation of a second degree curve for each zone is obtained, from which are calculated the values of $\frac{x}{x_c}$, $\frac{y-y_0}{y_m-y_0}$, and $\frac{y_c-y_0}{y_m-y_0}$ (where y_c = crude rate thrown up by the data). The values obtained from the different zones are then arranged in a single table in increasing order of x/x_c. Those from the East zone have however been excluded as its experience is quite exceptional in respect of the initial rise in the rates. This may be due to considerable heterogeneity in the data, as might appear reasonable in view of the constitution of the zone. The graduated values $\frac{y-y_0}{y_m-y_0}$ are already smooth, lying as they do on the curve given by equation (5.8), and they are now tested for adherence to data. The full working is given in Appendix B and it is found that equation (5.8) does indeed provide a good fit to the crude rates.

This may be taken as a reasonable confirmation of the original hypothesis of Professor Mahalanobis. As for the extension of that hypothesis, no statistical confirmation is yet possible in the restricted ranges of level of living and with the scanty data available for this study. Data for higher levels of living may however be available, when with the economic development of the country more and more people would be living at higher standards than they are doing at present. The consideration of this question has therefore to be postponed till such data are available and in greater volume than at present.

(c) *Estimation of response error.*(i) A reference to Table 6 will reveal the agreement between the three values of $I_{(c)}$ calculated by three methods. While the agreement between the first two values (cols. 1 and 2) establishes the consistency of the theory underlying this investigation, the agreement of the third value (col. 3) with the other two is of particular importance. It will be noticed that the value of l_0 (the coefficient of response error at lower educational standard) is derived from an equation (5.6) which involves the general fertility rates at lower and higher educational standards, and also the rates at different levels of living. No account has, therefore, been taken of the random errors underlying the rates which go to make up the equation. But if the value of l_0 derived from this equation applied to another rate (general fertility rate at lower and higher educational standards combined) subject also to random error, reproduces the correct rate as obtained by the previous methods and that too in all the zones, it seems reasonable to conclude that since the same data are analysed in two classifications, (a) according to level of living and (b) according to educational standard, the random errors in both sets of derived rates are so correlated that in using them jointly, stable results may be obtained. The values of l_0 obtained by the process described above may therefore be looked upon as a reliable estimate.

(ii) The coefficients of response error are to the nearest integers 19, 16, 14, 3, 2, and 5 in the East, South, North-West, Central, West and North zones respectively. The wide divergence in the zonal figures might seem peculiar but it will be noticed that the zones fall into two distinct groups, (a) East, South and North-West zones where the error coefficients vary between 14% and 19% and (b) North, West and Central zones, where they vary between 2% and 5%. These figures, in effect, represent the difference in the mental abilities of literate and illiterate groups in the different zones. If this pattern of figures be confirmed by a study with wider data as suggested in Section 2, it may be an interesting subject for investigation as to whether the change in the mental acumen or alertness produced by imparting the same education to illiterate persons belonging to different regions should depend on the possibly different social and ethnical characteristics of those regions.

6. LEVEL OF LIVING AND BIRTH RATE : NATIONAL INCOME STATISTICS, FIVE YEAR PLANS

6.1 The question naturally arises how the general fertility rate or the birth rate of the Indian population should be affected by an improvement in the standard of living in the country. A method of obtaining an approximate solution is given below.

If in a rural zone $I_{(0)}, I_{(1)}, I_{(c)}$ be the general fertility rates (as defined before), y_0, y_1, y_c be the corresponding average levels of living of the groups and $\bar{p}, \bar{q}$ be the respective proportions of all married women, at educational standards (0) and (1) and above (already defined), we have

$$I_{(c)} = \bar{p}\, I_{(0)} + \bar{q}\, I_{(1)} \text{ and } y_c = \bar{p}y_0 + \bar{q}y_1.$$

Now, if there be the same proportionate increase (say, $100k\%$) in level of living at all levels, leaving the relative distribution of the population according to level of living and to educational standard unaltered,

$$\Delta y_0 = ky_0, \quad \Delta y_1 = ky_1$$

and

$$\Delta y_c = \bar{p}\Delta y_0 + \bar{q}\Delta y_1 = k(\bar{p}y_0 + \bar{q}y_1) = ky_c.$$

Further,

$$\Delta I_{(c)} = \bar{p}\Delta I_{(0)} + \bar{q}\Delta I_{(1)}.$$

Assuming that the relation between I and y is approximately linear,

$$\Delta I_{(0)} = \frac{I_{(1)} - I_{(0)}}{y_1 - y_0}\, \Delta y_0 = m\Delta y_0 \text{ where } m = \frac{I_{(1)} - I_{(0)}}{y_1 - y_0}.$$

Similarly,

$$\Delta I_{(1)} = m\Delta y_1$$

$$\therefore \quad \Delta I_{(c)} = \bar{p}\cdot m\Delta y_0 + \bar{q}m\Delta y_1 = m(\bar{p}\Delta y_0 + \bar{q}\Delta y_1) = m\Delta y_c = mky_c$$

$$\therefore \quad \text{Increase in G.F.R. (All-India Rural)} = \frac{\Sigma N \Delta I_{(c)}}{\Sigma N} = \frac{k\Sigma N m y_c}{\Sigma N}$$

where N = number of married women in the zone, and increase in the crude birth rate (All-India Rural)

$$= \frac{k\Sigma N m y_c}{\Sigma P} \qquad \ldots \quad (6.1)$$

where P = population of the zone and Σ extends over all the zones.

6.2. Calculations based on (6.1) show that by a uniform increase of 20% in the level of living ($k = .2$) in all the rural zones, the birth rate should decline by about 1 per 1000 persons per annum. Considering the paucity of data and the approximations and assumptions involved in the above method, only broad conclusions may be drawn, viz., that improvement in living standards would tend to lower the birth rate but that the decline produced would indeed be small or insignificant. This view is supported by the opinion of A. J. Coale and E. M. Hoover,[8] that India and some other countries are not expected in the next two or three decades to attain such a state of economic development at which fertility would start on a definite downward trend, as it did in the past in other now well-developed countries.

6.3. We may now see how the average level of living may have moved in the years following the period 1941-50 by consideration of the following table and other relevant data.

TABLE 10. NATIONAL AND PER CAPITA INCOME AT 1948-49 PRICES*

year	national income	per capita income
(1)	(2)	(3)
1948-49	100	100
1950-51	102.3	99.8
1953-54	115.9	108.8
1956-57	127.2	114.8
1957-58 (preliminary)	125.2	111.6

*From Tables 73 and 74, pp. 183-84, *India 1960*, The Publications Division, Ministry of Information and Broadcasting, Government of India.

If we assume that saving had been at the same level from 1948-49 to 1953-54, the figures for per capita income would represent the relative values of per capita consumption for these two years. As it is consumption that determines the standard of living, we may assume that from 1948-49 to 1953-54 the average standard of living of the Indian population in real terms has gone up by about 9%. This figure will be smaller if saving has increased between these two years as is perhaps the case in view of the First Five Year Plan commencing to operate in 1951. It will be still smaller if the growth rate of the population during the quinquennium from 1948-49 has exceeded (which it certainly has) 1.3%, the rate for 1941-50 (see Table 8), which is assumed in arriving at column (3) from column (2) in the above table.

As for the period 1951-61, the above table shows an increase of per capita income of about 15% in 1956-57, which decreases to about 12% in 1957-58. However, according to the review of progress under the First and Second Plans,[9] over the 10 years 1951-61, national income (at constant prices) will have increased by about 42%, per capita income by about 20% and per capita consumption by about 16%. Here also from the first two figures it appears that the growth rate has been assumed to be 1.7%. The correctness or otherwise of the assumptions will of course be tested after the results of 1961 census are available. It may be mentioned here that the growth rate (1953-54) nearly at the mid-point of the decennium 1951-61 obtained from this study is 2.14% (Table 8) and if the actual growth rate has in fact exceeded 1.7% during this period, the increase in per capita consumption would be smaller than 16%.

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[8] A. J. Coale and E. M. Hoover, *Population Growth and Economic Development in Low-Income Countries*, p. 16, Oxford University Press, 1959.

[9] Third Five Year Plan—A Draft Outline, p. 17, Planning Division, Government of India, June 1960.

Looking forward to the Third Five Year Plan its objectives[10] are to increase the national income by over 5% per annum and to permit consumption to rise at the rate of over 4% per annum. The aim therefore is to secure at constant prices over the period 1951-66, an increase in the national income by about 80% and increases in per capita income and consumption by about 40% and 30% respectively. Here again, the basis is an assumed growth rate of 1.7% during the whole period of 15 years which seems to be unreal as the rate (1961-66) should exceed that for 1951-61 due to continuous drop in mortality rates.

6.4. On the above mentioned or any reasonable prospects of improvement in the standard of living, the birth rate should be practically left unaffected, but the point may be tested by a study of the consecutive rounds of the NSS in successive groups on the lines suggested in Section 2.

In this connection, we may refer to the *Demographic Year Book*, 1956,[11] where the reduction of mortality has been stated to be the most significant demographic event during the last decade and the accelerated population growth, which is greatest among countries with high rates of population increase has been explained by the stabilisation of birth rates and the fall of death rates. The fall in the death rate from 1941-50 to 1953-54 (Table 8) is quite substantial while the birth rates are practically at the same level, the growth rate (1953-54) found in this study thus being 2.14% per annum. It may be noted that the general fertility rate, birth rate and death rate found in this study for the North zone (NSS 7th round, 1953-54) are almost the same as those estimated for that zone in the Sample Census of births and deaths (1953-54).[12] As it is likely that similar confirmations should also exist for other zones, we may have some confidence in stating that an annual growth rate of the order of 2% (followed by a subsequent increase) may be expected to be revealed by a study of the different rounds of the NSS as already indicated, and also from the results of the 1961 census when available.

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[10] Third Five Year Plan—A Draft Outline, pp. 10, 17, 44. *Ibid.*

[11] *Demographic Year Book*, 1956, Statistical Office of the United Nations.

[12] Census of India, Paper No. 1, 1955.

Appendix A

1. Working with unweighted data the equation of the 2nd degree curves to fit the rates in individual zones are obtained as follows :

zone	equation
East	$I_x = .2304 - .00850x + .00038x^2.$
North	$I_x = .1530 + .01213x - .00033x^2.$
South	$I_x = .1652 + .00155x - .00005x^2.$
West	$I_x = .1275 + .00921x - .00024x^2.$
Central	$I_x = .1584 + .01149x - .00030x^2.$
North-West	$I_x = .1031 + .01471x - .00027x^2.$

where I_x=general fertility rate (married women) at level of living x. It will be observed that the coefficient of x^2 is very small compared to that of x and more so compared to the absolute term. This justifies the approximate relation obtained in equation (5.3).

2. Applying the method described in 5.3 we have an equation (higher powers of l_0 and l_1 than the second being neglected) for each of the zones as shown below.

East zone : $172.3\ l_0 + 161.1\ l_0^2 = 38.2 + 210.5\ l_1 + 221.7\ l_1^2 - 22.4\ l_0 l_1$ and assuming $l_1 = 0$, $l_0 = .188$.

North zone : $180.9\ l_0 + 184.0\ l_0^2 = 8.7 + 189.6\ l_1 + 186.5\ l_1^2 + 6.2\ l_0 l_1$. and assuming $l_1 = 0$, $l_0 = .046$.

South zone : $116.1\ l_0 + 114.8\ l_0^2 = 22.1 + 138.2 l_1 + 139.5\ l_1^2 - 2.6\ l_0 l_1$ and assuming $l_1 = 0$, $l_0 = .164$.

Yorth-West zone : $861.0\ l_0 + 869.1\ l_0^2 = 139.9 + 1001.0\ l_1 + 992.9\ l_1^2 + 16.2\ l_0 l_1$. and assuming $l_0 = 0$, $l_0 = .142$.

Central zone : $181.0\ l_0 + 165.7\ l_0^2 = 5.0 + 186.0\ l_1 + 201.4\ l_1^2 - 30.8\ l_0 l_1$. and assuming $l_1 = 0$, $l_0 = .027$.

West zone : $156.1\ l_0 + 155.1\ l_0^2 = 3.6 + 159.8\ l_1 + 160.8\ l_1^2 - 2.1\ l_0 l_1$. and assuming $l_1 = 0$, $l_0 = .022$.

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[a] As a check in each case the value of l_0 (together with $l_1 = 0$) is applied to and found to satisfy the original equation.

[b] In each of the equations above, on the right hand side in addition to the positive absolute term, the coefficients of l_1 and l_1^2 are greater than the corresponding coefficients of l_0 and l_0^2 on the left hand side. Hence l_1 must be greater than l_1 substantially. The presence of a positive term involving $l_0 l_1$ further strengthens this point. In cases, where the term is negative, the point is not materially weakened as the coefficient of the term is always small compared to the coefficients of the other terms of second degree.

Appendix B

TESTS OF GRADUATIONS (ADHERENCE TO DATA)

zone	x/x_c	exposed to risk E	$\frac{y_c-y_0}{y_m-y_0}$	$\frac{y-y_0}{y_m-y_0}$	(4)−(5) $\frac{y_c-y}{y_m-y_0}$		(3)×(6) $\frac{E(y_c-y)}{y_m-y_0}$		approximate s. e. $\frac{\sqrt{Ey(1-y)}}{y_m-y_0}$	$\frac{(7)^2}{(8)^2}$	$(8)^2$	$\sqrt{(\Sigma(8)^2}$ approximate s. e. of group deviation
(1)	(2)	(3)	(4)	(5)	(6)		(7)		(8)	(9)	(10)	(11)
					—	+	—	+				
N	.088	276	.1511	.1672	.0162		4.47		49.4	.0081	2440	
C	.091	226	.1532	.1741	.0209		4.72		47.8	.0098	2285	
S	.154	140	.3755	.2829		.0926		12.96	111.0	.0135	12321	
NW	.212	207	.3794	.3794	—	—	—	—	27.9	—	778	
W	.265	209	.4356	.4605	.0249		5.20		55.8	.0087	3114	
N	.411	106	.6576	.6527		.0049		.52	34.5	.0003	1190	
C	.520	201	.8394	.7699		.0695		13.97	51.1	.0747	2611	$\sqrt{(6703)}$
							(55.92)					=82
W	.653	94	1.0489	.8794		.1695		15.93	40.7	.1529	1656	
N	.669	102	1.1399	.8899		.2500		25.50	35.3	.5210	1246	
S	.720	115	.5813	.9208	.3395		39.04		107.0	.1334	11449	
NW	.749	115	.9367	.9367	—		—		24.6	—	605	
W	.929	81	.7994	.9958	.1964		15.91		38.6	.1703	1490	$\sqrt{(4510)}$
C	1.003	104	.8645	.9992	.1347		14.01	(64.38)	38.0	.1358	1444	=67
N	1.102	125	.7138	.9895	.2757		34.46		39.7	.7526	1576	
S	1.210	98	1.3529	.9542		.3987		39.07	98.9	.1558	9781	
NW	1.505	194	.7442	.7442	—			—	30.6	—	936	
W	1.593	208	.6766	.6497		.0249		5.17	58.0	.0080	3364	$\sqrt{(5755)}$
C	1.760	97	.4712	.4226		.0486	(22.83)	4.71	33.2	.0201	1102	=76
N	1.870	139	.3360	.2428		.0932		12.95	35.9	.1305	1289	
S	1.883	173	.1440	.2186	.0746		12.91		123.0	.0111	15129	
									−130.72	1081.0	2.3065	75806
									+130.78	.8×1081	(χ^2)	6.$\sqrt{(75806)}$
									261.50	=865		=165

1. *Changes of sign of deviations* (ignoring nil deviations) − − + − + + + + − − − + + + + − (sequence of deviation + or − total 17) 0 1 1 1 0 0 0 1 0 0 0 1 0 0 0 1 (6 changes of sign (1), 10 non-changes (0) total 16).

If x stands for no. of changes of sign, $x \;\dot{\frown}\;$ Bin $(16,\frac{1}{2})$, $E(x)=8$, $\sigma_x=2$. and $\frac{|6-.5-8|}{2}=\frac{2.5}{2}=1.25$.

Thus the number of changes of sign is not small enough to suggest over-graduation.

2. *Individual or group deviations:* Everywhere, the individual deviation is less than its standard error, and over the ranges where successive deviations are of the same sign, the total deviation (+ or −) falls below the group standard error $\sqrt{\Sigma(\text{S.E.})^2}$ This is a good feature of the graduation.

18 deviations are less than $2/3x$ standard error (probable error) while only 2 exceed that value. This suggests under-graduation of the data.

3. *Mean deviations:* The total of deviations regardless of sign $=261.5$, its mean $=865$ and standard error $=165$.

$$\frac{|261.5-865|}{165}=\frac{603.5}{165}=3.65$$

Thus the total of deviations regardless of sign is low and suggests under-graduation.

4. χ^2 *test:* $\chi^2=2.307$. The method of graduation has imposed 3 constraints for each zone, so that the total number of constraints $=3\times 5=15$ and the degrees of freedom $=20-15=5$. The probability that $\chi^2_5 \geqslant 2.307$ lies between .95 and .50, so that the fit of the curve to the data may be considered quite satisfactory.

The suggestion of under-graduation from the probable error and mean deviation tests, is not supported by the χ^2 test and by itself is of no consequence, as the graduated rates are smooth having been obtained by fitting a mathematical curve to the data.

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THE SOCIAL TRANSFORMATION FOR NATIONAL DEVELOPMENT

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1. INTRODUCTION

1.1. The problem of improving the material and cultural conditions of the poorer countries of the world has been engaging serious attention during the post-war period. The desire for political independence is rapidly increasing and will continue to grow in the countries still under colonial rule. Also, more and more countries are becoming and will become politically independent. With the gaining of independence, it is being increasingly realized that political freedom is necessary, but is not enough. In most of the underdeveloped areas, attention is being given increasingly to economic development to improve the level of living, by increasing the flow of goods and services and by expanding facilities for cultural amenities. It is also being increasingly appreciated that rapid economic growth can be brought about only by an increasing accumulation of capital to supply modern tools and machinery for new and expanding productive activities which would, in time, solve problems of unemployment or under-employment, and would also continually improve the level of living. Such accumulation of capital would call for increasing domestic savings, and the utilization of such savings for productive purposes. The choice of productive activities (that is, of investments) must also be such as to secure the best possible rate of economic growth over a time horizon of a generation or more.

1.2. How to bring this about? This is where the question of social transformation becomes relevant. Some broad general principles may perhaps be stated with confidence.

2. THE STRUCTURAL TRANSFORMATION

2.1. It is necessary to give opportunities for participation in productive activities to the largest number of people, and as soon as possible, to all such people as are capable of undertaking such work, and also to utilize available resources in the most effective way for the benefit of the nation as a whole. To create fullest opportunities for rapid growth, it is necessary to remove all barriers to the effective utilization of productive forces, by the people, for the benefit of all the people of the country.

2.2. There are many facets to the problem, some of which are general and some peculiar to particular countries. It is not possible to arrange them in any clear order of priority. In fact the heart of the problem is to make changes in all necessary directions at the same time, in a balanced way, so as to bring about the structural transformation as quickly as possible.

2.3. The transformation of the social structure cannot be an entirely internal process. Outside influences have been and will continue to be at work. Colonial rule and economic exploitation of the underdeveloped countries have themselves given rise to reactions promoting the desire for political independence and for improvement in the level of living in the underdeveloped areas.

2.4. A new factor, of conscious international cooperation in improving the social, political, and economic conditions of the underdeveloped countries, has also emerged during the last ten or fifteen years through a quickening of the world conscience on humanitarian grounds and also in the enlightened self-interest of the more advanced countries. Isolation is no longer possible, physically, psychologically or organizationally. The influence of information, ideas, advice and aid from outside would be an increasingly important factor.

2.5. A structural transformation of the whole society is, however, indispensable to make conditions fit for rapid economic growth. Without such transformation, any amount of help from outside would be ineffective. The experience of many countries during the post-war period would corroborate this.

3. THE SCIENTIFIC REVOLUTION

3.1. It is also necessary to develop the outlook of science and the experimental attitude of mind in order to acquire knowledge of natural and social forces and to invent new techniques for initiating material and social changes. This is the only way in which decisions can be made increasingly in a rational manner, in accordance with principles of objective or scientific validity based on relevant data and correct reasoning, instead of on the sanction of authority based on status and power or custom and conventional or revealed rules and laws. This may be called the scientific revolution.

3.2. The need of what I have called "the scientific revolution" is recognized, but has not received sufficient attention. I have considered some aspects of this problem in an attached note on "The Scientific Base of Economic Development."

4. MODERNIZATION OF SOCIETY

4.1. The social transformation and the scientific revolution are both necessary. These are but two aspects of modernization which can be distinguished but not separated. The social transformation and the scientific revolution in combination leads to modernization. The task of international cooperation is to promote and help, in every possible way and in a peaceful manner, the modernization of the underdeveloped countries.

4.2. *Urgency of the task :* The scientific and industrial revolution took place in West Europe and North America roughly over a period of three or four hundred years. It is not possible to wait for such a long time for the underdeveloped countries to attain a reasonable level of living. The historical process of transformation must proceed five or ten times faster. Such speeding up of the process of transformation has always been a characteristic feature of biological evolution, and can be achieved.

4.3. *Different phases of the transformation :* Some of the newly independent countries are large, some are of medium size, and some are extremely small in area, or in natural resources or in population. They would have widely differing needs. The particular form and contents and components of each step of modernization would depend on the special conditions of each country and the stage of development reached by it, and would therefore, vary from one country to another or from one region to another of the same country and also, over a period of time, in the same country or in the same region.

4.4· *International cooperation :* The most significant fact of the present age is the rapidly expanding contacts between different countries of the world. This tendency is bound to become stronger in future, increasing the scope of international affairs in every direction. At the same time, what George Washington had said about "no country being able to go beyond its own self-interest in international affairs," would continue to remain valid. The real need is, therefore, to discover new areas of mutual self-interest, and to expand spheres of common interest on both bi-lateral and multi-lateral basis to the fullest extent.

4.5. It is also clear that even the most advanced countries still have unlimited scope for both social and scientific progress. For all countries, large or small, advanced or underdeveloped, international cooperation is necessary and beneficial. The smaller and the less-developed a country, the greater however will be the need and importance of such cooperation.

5. Problems of internal reforms

5.1. There is general agreement about some of the most important contents or elements or aspects of the social transformation, such as :—land reform; removal of social, economic and political barriers; mass education and technical training; increasing equality of opportunities; the possibility of a labourer or an initiator securing the fruits of his labour; or the need of medical and health services and cultural amenities etc. There is much in common in respect of such components or aspects of social transformation in the case of all underdeveloped countries, with, however, the need of adaptations to suit the special conditions of each individual country. Some of these components or aspects are briefly considered below.

5.2. *Land reform :* Historically, land reform has been a most important factor in the economic development of all advanced or rapidly developing countries. Agriculture and industry must advance at the same time. It is, however, generally agreed that an agricultural surplus (or, the surplus from extractives) is essential for industrial development. Changes in land tenure and legislation would, therefore, be one of the requirements of the highest priority in most, if not all, underdeveloped regions.

5.3. The aim must be to secure the fruits of his labour to the cultivator so that he has the incentive to improve the land and to introduce more advanced technological methods. Tenancy law should protect the tenant against eviction so long as he is using the land efficiently, and to secure to him the right of fair compensation upon termination of the lease for all unexhausted improvements made by him. It is also necessary to eliminate the unproductive consumption of the surplus from land by intermediaries and landlords, who have no productive functions, by abolishing their rights.

5.4. The question of economy of scale of production may, admittedly, introduce difficulties. The breaking up of large farms may lead to a reduction of the surplus; however, the beneficial effects of greater equality of income and wealth may compensate for the other loss. Also, in countries where there are too many cultivators, often with scattered plots, further breaking up of the holdings may easily have adverse effects on the efficiency of production. In such a situation it may be necessary to promote consolidation of holdings either voluntarily through cooperatives, or by legislation, or both. Redistribution of land has limits and is a complicated question. It is wise to recognize that steps taken at one stage may have to be reversed at a later stage. Appropriate measures must be devised to suit the needs of each country at any particular stage of development. The basic aim would always remain the same, namely, to increase the agricultural surplus, and to use it for productive purposes, as effectively as possible, in speeding up the growth of the economy as a whole.

5.5. *Removal of social, economic, legal and political barriers :* The underdeveloped countries have the very difficult task of achieving a far faster rate of growth than had been achieved by the most advanced countries during and after the industrial revolution. It is indispensable that every one in the working age-group should be fully utilized to increase the national product. It is necessary, therefore, to remove all social, economic, legal and political barriers which prevent individuals, or groups and sections of individuals, to become fully productive. Conditions are worst in a country stratified by caste, colour, creed or language, and where whole sections of people are sometimes deprived of opportunities by customs, law, or social and political pressures by ruling groups. Removing all such barriers is an essential condition for rapid growth.

5.6. *Equality of opportunities and vertical mobility :* Removal of social and other barriers, in principle, is necessary but not sufficient. It is essential to help every one to make himself fit for the highest type of productive work of which he is capable. Opportunities for education and training and for productive work must be made as widely available as possible. Great inequalities of wealth and income often lead to denial of opportunities to the poorer people, and, unless removed, give rise to a sense of frustration among the under-privileged and hamper the growth of national solidarity. Sufficiently rapid economic progress would be difficult or impossible in societies in which there is lack of vertical mobility and where small sections try to preserve their privileges based on heredity, custom or law without any relation to their productive contributions.

5.7. *Horizontal mobility :* The social system may also hamper the utilization of resources because customs or caste restrictions prevent labour from moving into new occupations, or labour is tied to the soil, or land may be concentrated in the hands of small sections of the people who are unwilling to divert it for more productive use for reasons of social or political prestige. A small number of producers even in underdeveloped countries may sometimes band together to prevent the free entry of others or the introduction of new techniques. All such restrictions must be removed to increase the horizontal mobility of resources.

5.8. *Possibility of securing fruits of labour and enterprise :* The elimination of concentration of social, economic or political privileges in the hands of small sections of the people would promote both vertical and horizontal mobility, and make it possible for every one to secure a fair share of the fruits of his labour and enterprise. This is one of the most important consequences of the social transformation and is particularly helpful in promoting rapid economic growth. Appropriate legal and institutional changes must be made to achieve this.

6. NATIONAL INTEGRATION

6.1. *Sectional interests and barriers :* A characteristic feature of underdevelopment is the segmentation of the country into innumerable regions, castes, tribes, languages, religious communities, occupational and other groups which focus attention on the welfare of small sections of the people without any awareness of the best interests of the country as a whole. It has to be recognized that rapid progress is impossible without painful adjustments and damage to sections of the people whose interests are based on special privileges or old techniques; and that old beliefs, customs, and social institutions have to be discarded, and all barriers of caste, customs, creed, colour, language and sectional interests must be ruthlessly eliminated. The greater the prevalence of such social barriers in the country, the greater are the sectional rigidities within government administration, and the fiercer are the inter-agency jealousies and fights which continually delay decisions and hamper speedy action.

6.2. *Integration :* The removal of social and economic barriers is an indispensable condition for the emergence of the sense of national solidarity without which national development is impossible. It is not possible to isolate the scientific, or the social, or the industrial aspects of the transformation from one another. Advance must be made at the same time on all fronts. This creates difficulties but also has its advantages. Progress in one direction stimulates and promotes progress in another direction. It is the task of leadership to maintain a proper balance between the different aspects and phases of the process of modernization in its full sense. The aim continually must be to create a society from which social, economic and political privileges have been completely eliminated. To bring about such a transformation would call for wise leadership with a clear appreciation of aims and objectives, a rational and experimental attitude of mind with confidence in the outlook of science, and willing to pay the price of much painful adjustments.

7. Danger of superficial imitation of advanced countries

7.1. Because of the sense of urgency for economic growth which is strengthening everywhere, there is a peculiar danger of adopting, in a superficial way or at too early a stage, methods, and forms and institutions, which are working successfully in the advanced countries. It has to be kept in mind that existing social and political institutions, or high levels and standards of quality or performance, were established in the advanced countries only with the gradual growth of the economy. Such institutions may not be useful at an earlier stage of development, and may even hamper progress. For example, in underdeveloped countries, there is sometimes a tendency to adopt too expensive or too sophisticated schemes of education, care of health, public buildings and construction, wages or salaries of government employees or labour legislation.

7.2. *Education and training :* Mass education to spread literacy both among children and adults has special urgency; here all possible help should be utilised, for example, by using the services, for a small part of the day or the week, of those who are already literate. Because the numbers involved are very large, the adoption of too high a standard for teacher qualifications, school buildings etc., at the primary level, would make the cost prohibitive. At the secondary stage, more attention would have to be given to the qualifications of teachers and other educational aids; but scales of pay or cost of buildings should still be kept in balance with the general level of living of the students and the parents themselves. At the tertiary level, still higher standards would have to be adopted for staff qualifications and there would be need of more expensive teaching aids; but the expenditure must be kept within the limits of what the country can afford. It is at the stage of advanced studies and research that standards should be really high and comparable with the advanced countries; however, as the number of advanced and research workers would be very small in the beginning, this would not involve any large total expenditure.

7.3. The educational system should be viewed as a pyramid; the lower the stage the wider should be the base (that is, the number of persons under instruction) and the lower the scales of expenditure compared to advanced countries, while at the highest stage of advanced studies and research the number involved would be extremely small but scales of expenditure may approximate to those of advanced countries. Adoption, at too early a stage, of standards and scales of expenditure of advanced countries at lower levels would lead to severe restrictions in numbers usually coupled with admission of students on the basis of family income; this must have most undesirable social and psychological consequences. When resources in men, materials and money are inadequate, to increase the number of students in accordance with the pressure on admissions, would necessarily lead to window dressing and a dilution of standards in practice. This can seriously hamper progress; the only remedy is to adopt a system which would be in keeping with basic aims and yet within the means of the country.

7.4. *Medical care and technical services :* A similar situation can arise even more easily in the field of medical care. Adoption of the high level of university education for physicians in the advanced countries as the only standard at an early stage would necessarily mean that most of the people will be deprived of medical services in underdeveloped countries for a very long time. A two-tier approach with a junior cadre of medical personnel with, say, three or four years' training, together with a much smaller number of physicians with university training, would make it possible to spread medical services much wider and much faster. This would be equally true in many other lines of technical work. A two or even a three-tier approach with a higher, a medium, and even a third level of workers who have had a very quick and specialized training, would be not only within the means of the underdeveloped countries but may be even more effective, because, in the still backward conditions of the country, the lower level workers would be much nearer to the general population and would be able to work in closer touch with them. This would be particularly true in agricultural extension and other services which would bring the technical workers into contact with large sections of the population.

7.5. *Government expenditure :* Government expenditure often tends to become unduly large in underdeveloped countries owing to the adoption of the much higher standards of advanced countries. This leads to unnecessarily high scales of wages and salaries for government employees or costly public buildings; which, in its turn, would increase the feeling of separation between government and the people, and hamper national integration.

7.6. *Labour legislation :* As production becomes modernized and factories and enterprizes grow in numbers and in size, it would be necessary to develop labour legislation and regulations to ensure that labour secures a fair share of the surplus, and also to ensure working conditions being maintained reasonably safe and healthy. Legislation in imitation of the more advanced countries, at too early a stage, may, however, lead to increasing inefficiency of performance, especially, in countries with surplus labour, and may increase costs of production so much as to have serious adverse effects on exports. The most important thing is to establish a definite link between remuneration and output in the case of all types of work of which the volume and quality can be estimated even roughly. It is necessary to recognise that trade union movements can gain in real strength only on the basis of increasing productivity.

8. NATIONAL LEADERSHIP

8.1. The transfer of modern technology from the advanced countries also calls for much adaptation to suit the needs and local conditions of underdeveloped regions. To profit by the experience of the advanced countries and yet to introduce modern technology and modern social and political institutions in a way suitable to the particular stage of development of the country is a matter of crucial importance in the process of modernization. Ultimately, success would depend on the growth of a rational outlook and the experimental attitude of mind, first, among the leadership at all levels and then gradually among the general mass of the people.

8.2. It is extremely important that the advanced countries should help and encourage in every way all progressive groups within the country in promoting the process of modernization and refrain from offering technical or economic aid in any way which would hamper the social and scientific transformation.

THE SCIENTIFIC BASE OF ECONOMIC DEVELOPMENT

1. PHASES OF ECONOMIC DEVELOPMENT

1.1. The essential characteristic of an underdeveloped country is an extremely low level of living, that is, inadequate supply of food, clothes, housing, drugs and other consumer goods, and also lack of facilities for education, care of health, social security, cultural amenities, etc., for the nation as a whole. It is possible to make available small quantities of consumer goods by direct imports or by domestic production, on a small scale, with the help of imported machinery. In most of the underdeveloped countries it is, however, not possible, for lack of necessary foreign exchange, to import or to produce, with imported machinery, enough consumer goods for the people as a whole. In India, the first textile mill was established in 1817; and India gradually became the second biggest producer of textiles, next only to America. One hundred and fifty years later, India would still remain underdeveloped. The production of textiles or small quantities of other consumer goods for a small part of the nation cannot, by itself, lead to industrialisation and economic development.

1.2. Economic development can occur only by increasing the per capita production of the nation as a whole, through an increasing use of machinery driven by steam or electricity as a substitute for human and animal labour. In countries with appreciable natural resources, it is necessary to establish the basic engineering and power industries to enable the manufacture of both consumer and capital goods within the country. Establishing a minimum complex of such basic industries would take at least ten or fifteen years, for which planning must start ten or fifteen years in advance.

1.3. To increase modern industrial production would call for an increasing supply of engineers, technologists, and technical personnel. The only way to ensure this would be to establish and increase the number of schools, training colleges and universities, and also to train teachers for such institutions. This would take at least fifteen or twenty years; so that planning for this purpose must start fifteen or twenty years in advance.

1.4. The best way of utilising the raw materials and natural resources available within the country, for both domestic consumption and for exports, can be found out only through applied scientific research.[1] Applied research, in its turn, must be based on advances in fundamental research. Also, to establish an adequate base for applied research it is necessary to promote the spirit of pure research and supply the stimulus of scientific criticism. This would be possible only when at least a certain minimum number of scientists are engaged in fundamental research, and opportunities for pure research are becoming increasingly available. It is therefore necessary to promote the advancement of both applied and fundamental research. To establish a minimum base for scientific research would take more than a generation of twenty-five or thirty years; this, being the most slowly maturing sector, must be given the highest priority.

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[1] Even the most advanced countries are obliged to devote large resources to research for the improvement of products already being manufactured and also to develop new products in order to hold their position in the world export market. It is not possible for the underdeveloped countries to start or expand the export of fully or partly manufactured products by simply borrowing the current technology from advanced countries; it is essential also to develop applied research for a continuing improvement of technological methods.

2. THE SCIENTIFIC BASE OF THE ADVANCED COUNTRIES

2.1. The scientific base of the modern age can be appreciated by even a brief review of the recent history of the advanced countries. Four hundred years ago the generally accepted view was that the earth was at the centre of the universe; the position of human beings was unique and supreme; and the highest sanction of truth was either divine revelation or abstract logical reasoning in the mind of man. In the sixteenth and the seventeenth centuries, there was a complete revolution in the picture of the physical world ; the earth was seen as a small planet moving round the sun; and the method of empirical observations and experimentation was gradually established in both physical and life sciences.

2.2. Progress was at first slow in the sixteenth century. A few selected names may be recalled to indicate the gradual transformation of ideas. In astronomy, Nicholas Copernicus (1473–1543) supported the view that the planets including the earth itself were revolving in orbits round the sun; Tycho Brahe (1546–1601) supplied astronomical observations of unprecedented accuracy to make the next steps possible; Johann Kepler (1571–1630) formulated the descriptive laws of planetary motion; and Galileo Galilei (1564–1642) made conscious propaganda in favour of the new philosophy of the universe. In anatomy, Andreas Vesalius (1514–64) published his observations on the human body in 1543; in physics, William Gilbert (1544–1603) gave an account of magnetism based on trustworthy experiments in 1600; in physiology, William Harvey (1578–1657) described the circulation of the blood in 1628; John Napier (1550–1617) supplied a convenient tool for computation by the use of logarithms; and Rene Descartes (1596–1650), a philosopher, contributed the powerful concepts of coordinates for geometrical representation and of mathematical functions. Francis Bacon (1561–1626), firmly stated that the only true method in science was to proceed from particular sense observations to wider generalizations (*Novum Organum*, Book I, xix), and clearly recognised that "the true and lawful goal of the sciences is . . . that human life be endowed with new discoveries and power."

2.3. The concept of an objective world of physical reality gradually took firm shape in the seventeenth century in the hands of gifted astronomers, mathematicians and scientists. A few names may be mentioned from among those who were born in the first half of the century; Pierre Fermat (1601–1665), Christian Huygens (1629–95), Blaise Pascal (1623–62), Robert Boyle (1627–91), John Ray (1627–1705), Robert Hooke (1635–1703), Issac Newton (1642–1727), and Gottfried Wilhelm Leibniz (1646–1716). The rate of advancement of science increased progressively in the eighteenth and the nineteenth centuries, and during the last few decades has opened new frontiers with almost unimaginable possibilities.

2.4. The advancement of science prepared the ground for the industrial revolution in Europe in the eighteenth century, first in spinning and weaving, next in the use of iron and steel, and then of electricity in the nineteenth century, which stimulated the growth of the capitalist economies in West Europe and North America. The spread of the scientific outlook also prepared the ground for the age of reason and the French revolution, which occurred at the end of the eighteenth century, and promoted the growth of nationalism in Europe, in its modern sense, in the nineteenth century.

2.5. The industrial revolution increasingly replaced human and animal power by steam or electricity to drive machinery for the increasing production of both consumer and capital goods. The development of engineering techniques led to a close linkage between science and technology; and during the last hundred and fifty years, industrial development is being stimulated by a scientific discovery or a scientific discovery is being stimulated by industrial needs.

2.6. For the last five or six thousand years, or more, the average per capita production remained more or less constant or fluctuated within narrow limits. The industrial revolution changed all this, and led to a spectacular increase in the variety and volume of goods produced. As a consequence of such increasing production, the standard of living of the advanced countries of West Europe and North America reached a level far higher than the rest of the world. Also, the advancement of science, technology and industry, made it possible for the western countries to become strong military powers; and, because of such military supremacy, the west was able to bring a large part of the world either into direct colonial rule or into conditions of economic or political subjugation.

2.7. The last forty years have also seen the rise of U.S.S.R., as another world power, rapidly growing, through the promotion of science and technology, in economic, industrial and military strength together with a continuing increase in the level of living. The monopoly of scientific and technological knowledge and the unchallengeable military supremacy of the western countries have now gone. The increasing parity between the "western" and the "eastern" countries in science, technology, industry, and military power is a most significant fact of the present time. Because of the unprecedented destructive power of atomic and nuclear weapons, it has become absolutely necessary to avoid a nuclear war which would be catastrophic for both sides and the whole world. Coexistence of both the "western" and the "eastern" powers has become indispensable.

2.8. There is no intention on either side to make a direct attack. The advanced countries pose no special problems because it is not possible to hold such countries indefinitely in subjugation. However, so long as there are underdeveloped areas, both power groups are likely to try to extend their influence over the less advanced countries; and this would remain a continuing source of potential conflicts. The very existence of underdeveloped countries should, therefore, be seen as a threat to peace. Rapid transformation of all the underdeveloped countries into modern viable societies is an essential condition for peaceful coexistence. Such a transformation would promote the enlightened self-interest of both power groups, and would also create conditions favourable for the advancement of human and cultural values on a world-wide basis.

3. THE ROLE OF SCIENCE IN THE MODERNISATION OF THE LESS ADVANCED COUNTRIES

3.1. Modernisation of the less advanced countries through rapid industrialisation is thus an urgent need of the whole world. Is such modernisation possible or can a modern society with a viable economy, with expanding social and political freedom, and cultural amenities, be sustained without establishing a sound scientific base? This is a question of crucial importance for the present age.

3.2. In order to answer this question, it is necessary to appreciate the deeper changes in human thinking which were brought about by the emergence of science. In every sphere of organised activity in human society, authority has always been associated, and must always be associated with a system of hierarchical levels. This applies to primitive societies, matriarchal, patriarchal, or tribal; successive levels of feudal lords; organised churches and religions; military, police and administrative systems; enterprises, business and commerce; and law. A law court of appeal may reverse the decision of a lower court; but the decision of the court of appeal is itself subject to change by a still higher court. The decision of the highest court, to which a case has been actually referred, has to be accepted not because such a decision is necessarily right, but because it is the decision of a superior authority.[2] Society must accept this authority principle for stability and orderly progress, even in organised revolutionary activities.

3.3. This very authority principle must, however, be absolutely and completely rejected in the field of science. Modern science is based on a patient accumulation of facts, on the study of processes and their interrelations or interactions and a stability or uniformity of nature[3] which can be discovered by the human mind. The findings of the most eminent scientists are subject to critical check by their professional colleagues and by the youngest scientific workers, and must be rejected if there is no satisfactory corroboration. Science can advance only through free criticism on a completely democratic basis, with every research worker of competence enjoying equal status. The theoretical or conceptual framework of science must be continually revised to find a proper place for all known facts. A single new observation may call for a more comprehensive theory. The older accumulated knowledge continues to remain valid ; later discoveries must, however, be integrated with the earlier knowledge. The accumulation of scientific knowledge is increasing through the efforts of all the scientific workers of the world. A new fact may be observed or a new theory formulated by any worker, however young, and in any country where research has been established. International collaboration is, therefore, an indispensable condition for the progress of science.

3.4. Authority derived from status is irrelevant to science. Science has introduced a new concept of "scientific", or "objective validity" which has its foundation in nature itself, and which cannot be upset by any authority based on status or by supernatural powers. The transformation of all the advanced or rapidly advancing countries has been based on accepting, in an increasing measure, a scientific or rational view of life. This is the foundation of the modern age.

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[2] It is possible, indeed, that this decision itself would have been reversed if there had been a still higher court to which the case could be referred. If a decision of a higher court of appeal is considered to be like the turning up of "heads" (in tossing an unbiased coin) when the decision upholds the verdict of the lower court, and is considered to be like the turning up of "tails" when the verdict of the lower court is reversed, then the successive decisions of the higher court would look like the results of the tossing of a coin. This would be the real guarantee that the system of law is functioning properly.

[3] The phrase "uniformity of nature" must be, of course, interpreted to include chance events and random processes. Although games of chance were known and were widely prevalent in ancient times in China, India and other countries, it is important to note that the concept of probability did not arise until the 16th and the 17th centuries, that is, not until the emergence of modern science. This is easy to understand. Before the emergence of the modern scientific view of an objective world of physical reality, all chance events would have to be necessarily ascribed to the whims of gods, demons, or supernatural forces. After the emergence of the scientific view of an objective world of physical reality, it became necessary, both logically and psychologically, for the human mind to accommodate the occurrence of chance events as an integral part of the uniformity of nature. This could be accomplished only on the basis of the theory of probability, or rather, as I should prefer to put it, only through a statistical view of the world. It seems to me, therefore, that the concept of probability, or the statistical view of the world, did arise at the same time as the emergence of modern science only because it could not possibly have arisen earlier.

3.5. It is essential in every country to establish and strengthen the outlook of science, a way of thinking which becomes more and more powerful as it is more widely adopted, and which replaces dogma, superstition, and outdated customs. This scientific outlook cannot be established by force. It must depend on acceptance through proper understanding. In practical affairs, the important point is that a wise policy and programme of action should be increasingly adopted on the basis of rational argument, supported by relevant factual evidence, and should not be rejected because of emotional bias or formal dogmas or conventional rules of procedures. It is, therefore, necessary continually to encourage and promote the advancement of science in every country, large or small. Because science is indivisible, and also because science must be established in every country, it is also necessary, continually, to promote scientific collaboration between all countries of the world, large and small, and advanced or developing.

3.6. It is scarcely necessary to point out that there is no conflict between the scientific and rational view of life, on one hand, and aims and objectives based on moral or cultural values, on the other hand. On the contrary, moral and cultural values which are truly universal, and are not narrowly sectarian or nationalistic in a restricted sense, must have an objective and rational basis.

3.7. The advancement of science and the growth of the scientific outlook must be recognised as an essential condition for the modernisation of the less advanced countries. It is necessary for each country to have, as quickly as possible, a sufficient number of men with a scientific outlook to influence the thinking of the nation. How to attract and hold a sufficient number of able persons to science is thus the crucial problem of national and world development. This can be achieved only through a proper and adequate social appreciation of science and scientists. The actual transformation must be brought about from within each country. Scientific aid from the advanced countries can, however, be of great help in this process.

4. PRESENT PROGRAMMES OF TECHNICAL AID

4.1. The need of technical aid has been recognised for some considerable time. Bi-lateral or multi-lateral and international technical aid has often taken the form of either offering educational and training facilities to young workers from the less advanced countries or sending technical or scientific experts to such countries. Considerable benefit has no doubt accrued through such aid but it is necessary to recognise that much effort has also been wasted.

4.2. Scholars from the less advanced countries are usually selected on the basis of results of examinations; success in examinations not being a necessarily reliable indicator of scientific or technical ability, the very process of selection is inefficient. Some of the young scholars have difficulty in adjusting themselves to the pattern of living in the advanced countries. Some of them do not do well in their studies. Some pass the examinations successfully but have no aptitude for scientific work. Some of the more able scholars prefer to live and settle down in the advanced countries, especially in the U.S.A., because of the higher level of living or greater opportunities for scientific work. Some scholars of ability, when they return to their own countries, are unable to find suitable openings for a scientific career; and some of them go back to the country where they were trained. In applied science and technology, and especially in social sciences, many young scholars, who had often studied problems or learnt methods which are appropriate for advanced countries but totally irrelevant to their own native countries, are unable to adapt or develop methods to suit local conditions. Out of the large number of scholars who go to advanced countries for training, only a very small number of really able scientific workers ultimately become available for fruitful work in their own country. The cost of giving scientific or technological training in an advanced country is also very high. Giving training to individual scholars in advanced countries (whether the expenses are provided in the form of foreign aid or met by the scholars themselves or by the country of origin) have been, therefore, extremely wasteful in terms of both men and money.

4.3. There has been also continuing difficulties in finding suitable individual experts for the less advanced countries. Competent scientific workers are reluctant to accept such assignments partly because of the lack of facilities for their own work in the less advanced countries and partly because their scientific or academic career is likely to be adversely affected through their absence abroad. In consequence, assignments sometimes have to be given to persons who are not fully qualified for the job, with unsatisfactory results. To create suitable conditions for scientific work in the less advanced countries is an indispensable condition for attracting competent scientists to go out to such countries.

4.4. Programmed technical aid on a group basis has been more effective. A team of young engineers from a less advanced country can receive most valuable training in an advanced country when such training is oriented to specific technological projects. Teams of experts from advanced countries have also been of very great help in establishing factories or in starting new projects in the less advanced countries. Such technical aid, especially in engineering, technology and applied sciences, should be continued and expanded. Special projects for establishing technological and research centres in the less advanced countries have also been taken up by some of the international agencies. This type of aid can be of great value provided a sufficient number of scientific workers in the less advanced countries can be trained to work in such centres, and also provided necessary conditions are established to enable them to do their work properly.

5. SCIENCE EDUCATION AND RESEARCH

5.1. It has been argued in the earlier sections that for modernisation it is necessary to establish a foundation for scientific research and the social appreciation of science in the developing and less advanced countries. Every path-finder in a new field of research must work in the first instance by himself; if he is successful, other persons gradually get interested in the subject. Such path-finders always had, and will always have to overcome much opposition, and even hostility, until the new subject becomes a recognised part of the "established" field of science. But it is only a few scientists of outstanding ability who can work in isolation. Most research workers require the stimulus of free interchange of views and ideas and of appreciation among professional colleagues.

5.2. The community of scientists has a structure of a series of widening circles similar to the structure of scientific subjects or of science as a whole. When a top scientist speaks appreciatively of some work in his special field, other scientists or lay men accept his evaluation and pass on the information to others. The social appreciation of science gradually emerges as a result of the diffusion, in widening circles, of the views of scientists, who are experts in specialised fields of research, to scientists in related and associated fields, then to scientific workers generally, and finally, through persons of position and standing who have contacts with scientists, to the general public. The speed with which such appreciation can spread increases rapidly with the increase in the number of scientific workers and improvements in the channels of communication. In the advanced countries, the awareness of the importance of science is increasing rapidly which, in its turn, is raising the social status of scientists and is promoting an increasing flow of resources for research.

5.3. The whole process is extremely slow in underdeveloped countries. The number of research scientists is very small; and channels of scientific communication are non-existent or meagre. Scientific workers usually receive lower pay and have a lower status than the administrative staff in government or in business concerns; and have to work in a rigid system of hierarchical authorities. Promotion may depend, not so much on the high quality of the scientific work done, but on success in pleasing those who are higher up in the official hierarchy. Even permission to apply for posts elsewhere is subject to the discretion of superior officers. There is a continuing tendency to bring scientists and scientific work under stricter control of the administrators, partly, perhaps, from an unconscious fear of rivalry of power. Even if the right of criticism is accepted in principle, it is restricted in practice because scientific workers are often afraid, rightly or wrongly, of giving offence to persons holding higher posts. In consequence, many scientists in underdeveloped countries suffer from a lack of self-confidence, and are afraid to take up original lines of investigation. There is little possibility of a proper evaluation or appreciation of scientific work within the country. This leads to an exaggerated dependence on the opinion of foreign scientists and gives rise to much imitative work. Also, when there is lack of appreciation or criticism from the advanced countries, there is sometimes a tendency to ascribe the unfavourable view to racial or national prejudices, and there is resistance against collaboration with foreign scientists.

5.4. In underdeveloped countries there are very few, sometimes only one or two, individuals of outstanding ability in scientific research or in any other scientific field. As leadership can be supplied only by individuals of high ability, and as such persons are few in number, it is much more difficult in underdeveloped countries to utilise the services of individuals of average ability and qualifications. The advanced and advancing countries have a double advantage. They have a large number of persons with qualities of leadership and can, therefore, utilise in a fruitful way larger numbers of persons of average ability. This is why many scientific workers from underdeveloped countries, who are unable to do much useful work in their own native country, can often do very good work in the environment of a higher state of organisation of research in an advanced country.

5.5. The aim of scientific aid must be to create in every underdeveloped country, as quickly as possible, a sufficient number of research scientists to form a community of professional workers which would be sufficiently large to facilitate an independent evaluation of scientific work through free criticism and frank exchange of views. It is, therefore, necessary to focus attention on identifying and giving support to persons who have the ability to undertake research work of high quality, and to try to increase their number as quickly as possible, and at the same time to offer opportunities for training to persons of average ability whose services would be equally essential in supplying a wide base for the pyramid of scientific work.

5.6. There is urgent need of fostering the spirit of objective scientific criticism through free expression and exchange of views and opinions. One effective way of promoting this would be to make it easy for scientific workers to migrate from one post to another and give an absolute guarantee of such freedom to migrate. Any scientific worker who feels, rightly or wrongly, that he has not enough opportunities for fruitful work in one institution would be free to migrate to some other institution. Such migrations or the possibility of such migrations would have an indirect but most important selective effect on scientists at all levels.

5.7. It is necessary to recognise that the social value of an individual scientist of high ability is far greater in a developing country because of the leadership he may be able to supply. It is only scientists engaged in fundamental research who can function as the eyes and ears of the nation in making the nation appreciate and identify urgent needs of applied research. The emergence of even one or two outstanding research scientists can enhance the prestige of the nation in a most significant way at the international level and promote the growth of self respect and self confidence of the nation. This is why it is particularly important in developing countries to identify such individuals, at first very few in number, and give them all possible facilities and encouragement to continue their work in their own country.

5.8. In the highly developed countries science advanced both from progress at the highest levels of research, at the top, and from the wide diffusion of education, at the bottom. The same strategy may be adopted with advantage in the less advanced countries. What is urgently needed is to lay the foundations, with as wide a base as possible, for a country-wide system of school education oriented to science and, at the same time, to develop advanced studies of science and technology and research at the highest level. The school system must fit into the economic life of the general mass of the people and have its grass roots in the villages. It must offer facilities for training technicians and technical personnel for science and technology and also supply candidates of outstanding merit for admission to higher scientific and technological institutions.

6. NEED OF DIRECT AID FOR SCIENCE

6.1. I shall offer, briefly, a few suggestions for giving direct aid for the development of science in the less advanced countries. I have stressed the need of building up a system of school education with a definite orientation to science. It would be, however, a fatal mistake to establish an expensive system of education on the model of the advanced countries which would have little relevance to local needs and would be beyond the means of the national economy. It is necessary to evolve a system, through experimentation and trial and success, which would be within the means of the national economy. The approach must be therefore to use teaching aids which are easily available or can be made available on a large scale and at a low cost. As most of the pupils will be living in villages, it would be of great advantage if agriculture and some of the rural industries can be adopted as a base for the teaching of science. The programme may consist largely of nature studies, observations, and experiments which can be done with the help of simple articles, specimens, etc., likely to be locally available or which can be constructed with local materials.

6.2. There would be still some need of supplying teaching aids and materials from outside which would have to be specially designed to reduce costs. It is essential also to prepare books of instructions and text books to suit a fairly wide range of needs. These are difficult tasks which would call for extended study and research by scientists of high calibre with a serious interest in problems of science education. As basic conditions in underdeveloped countries are likely to be similar to a large extent, it may be possible to evolve broad general methods for science education which would be capable of being adapted without much difficulty to suit differing local conditions.

6.3. A great deal of pioneering research would be necessary for this purpose for which the help of advanced countries is indispensable. A good deal of experimental studies will have to be undertaken under conditions actually prevailing in underdeveloped regions. In the beginning, the studies would have to be organised on a small scale with the help and support of the local authorities and of such teachers and scientists as may be available to cooperate in the venture in the underdeveloped country itself. The project can be gradually extended, in the light of experience, to cover different subject fields at different educational levels, and also from one underdeveloped country to another. Fortunately, even one or two scientists can start the work in one single country. The important point is to make a beginning at the earliest opportunity.

6.4. I may now mention a second type of programme. Certain facilities for scientific research are already available in India and other developing countries. In most of these countries, scientific work is being hampered for lack of small replacement parts, additional accessories and instruments, and supply of essential consumable stores which have to be imported from the advanced countries. It is often difficult to secure import licences on account of shortage of foreign currency. This difficulty can be overcome through a simple plan of gifts in kind of replacement parts, instruments and equipment, stores, books and journals and reprints or microfilms of scientific papers etc., to be arranged through non-governmental committees of scientists. Such committees, which can be set up in the advanced countries through or in cooperation with appropriate scientific organizations or societies, would try to secure suitable grants from Government and other sources. In developing countries where scientific research has already started, the counterpart committees of scientists would also be set up, preferably, at a non-governmental level and with a majority of members from universities and non-governmental scientific institutions. All arrangements would be made with the concurrence of the government of the less advanced country concerned, but decisions relating to gifts for scientific work must be made by direct consultations between the scientific committees themselves. A scheme of this type can be usefully started, on an experimental basis, for a few selected countries, at a low cost, with gifts to the total value of perhaps one or two hundred thousand dollars per year. The amount can be increased if the experiment proves successful.

6.5. Another important form of scientific aid would be to arrange for competent research scientists from the advanced countries to work for a year or two in existing research units in the less advanced countries or to help in establishing high level research units in such countries. The less advanced countries can offer challenging problems and opportunities for research in many fields of science, which cannot be duplicated in the advanced countries, for example, in geology, meteorology and geography; biology, botany, and zoology; agriculture; medical science and public health; economics of development; linguistics, archaeology; and historical and cultural studies of various kinds. In some of the developing countries there would be also increasing opportunities for active participation in research in mathematics and statistics, and physico-chemical and technological sciences. In establishing research units in underdeveloped countries it would be desirable to keep one broad aim in view, namely, to encourage joint studies by active collaboration between different research units. This would help in developing a community of research cells or units which, in its turn, would foster the growth of the spirit of scientific criticism and appraisal among wider circles of scientific workers.

6.6. To attract competent visiting scientists it is necessary to offer them facilities to pursue or start fruitful research in the less advanced countries ; sometimes special equipment may have to be provided for this purpose. Secondly, the assignment in a less advanced country, would have to be treated as deputation in the same way as participation in scientific expeditions, and which would be recognised as a part of normal duties and also as a possible qualification for promotion. The visiting sicentist must receive sufficient compensation in his home currency to meet his continuing home commitments during his absence abroad. Living and other local expenses should be normally met by the institution or by the government of the country in which he would work. Such sharing of costs would promote effective cooperation in the less advanced country, and would also reduce the total cost appreciably.

6.7. An important part of the responsibilities of a visiting scientist would be to give training to the scientific workers of the underdeveloped countries. When necessary, the visiting scientists would be able to select, for further training in an advanced country, the right type of persons who can be depended upon to go back to their own country after the completion of the training abroad. It would be also possible to give aid in the form of equipment and instruments in an effective way on the basis of objective appraisals of needs and possibilities by the visiting scientists.

6.8. A fourth programme could be to send from advanced countries young scholars, who have just finished their education in universities or higher educational institutions or have already done some research, to start or continue suitable lines of research for about two years or so in existing institutions or in research units to be established for this purpose in underdeveloped countries. The common participation in research projects of young scholars from the advanced and the underdeveloped countries would be of great help in establishing scientific traditions and an atmosphere of scientific criticism. It would promote self-confidence among the scientific workers of the underdeveloped country, especially, if the visiting scholars from advanced countries take higher degrees from institutions in the less advanced countries.

6.9. All the above forms of scientific aid can be started, if desired, on a small scale and at low cost, and, if successful, can be expanded in the light of experience. Also, these forms of scientific aid would not in any way overlap or hamper bigger programmes for gifts of expensive equipment or large projects for the setting up of national or regional centres and institutes for scientific research in the less advanced countries. On the contrary, the modest programme described in this note would prepare the ground for bigger projects.

7. CONCLUSION

7.1. In conclusion I may refer, very briefly, to some recent developments. After the second world war the movement for terminating colonial rule gained rapidly in strength; and one country after another in Asia and Africa has won political independence. It is being increasingly realised, however, that independence is not enough for economic development. The need of economic and technical aid is also being increasingly appreciated. Both the "western" and the "eastern" powers have started helping in the economic development of the less advanced countries in Asia, Africa and Latin America, but still without an adequate impact. The time has come to recognise that economic aid is essential but is also not sufficient.

7.2. Revolutions to capture political power have been occurring throughout human history and are even now occurring in many of the politically independent countries in Latin America or in most of the newly independent countries in Asia and Africa. Such revolutions do not automatically promote rapid economic development, because purely political revolutions do not lead to any fundamental transformation of the old society based on the principle of authority associated with levels of status. It is becoming increasingly clear that rapid economic development cannot be achieved without developing a structure of society in which decisions would tend to be made more and more on grounds of reason, that is, in accordance with the principle of objective validity instead of authority. It is relevant to note that the French Revolution was preceded by the age of reason; the American War of Independence had the support of influential leaders inspired by the spirit of science; and the socialist government, which was established after the October Revolution in 1917 in Russia, made great efforts to build up a countrywide system of science-oriented education and to promote scientific research and, in this way, succeeded in modernising the whole society leading to rapid economic development.

7.3. One thing is clear. In the absence of rapid economic development, political conditions in the less advanced countries would remain unstable. In many or most countries there would be one revolution after another tending to get the two power groups involved directly or indirectly in the struggle. The world must get out of this vicious circle. There are only two possibilities. One is for a violent type of revolution to occur which would suddenly change the whole structure of society to make it fit for rapid development of science and economic progress. The other alternative is deliberately to build up the foundation of science-oriented education and research to promote the modernisation of society in a peaceful way, and make conditions favourable for economic development.

7.4. Aid for scientific and economic development from either the western or the eastern countries, even when given in a spirit of competition, would be cooperative in effect. In any event, competition in constructive tasks of building up scientific foundations in developing countries is less dangerous and is likely to be far more useful than competition in the methodologies of warfare. Also, collaboration in promoting education and research in pure science can be pursued without any threat to national security or national interests, and would be of great help in promoting a rapid advance of the underdeveloped countries and in fostering better understanding among the nations of the world. The advanced countries have a great opportunity for peaceful cooperation in giving aid for science.

Certain aspects of the problems mentioned in this paper were discussed by me in articles and addresses between 1955 and 1959 which were printed in my book *Talks on Planning* (published in 1961), and in other articles such as *A Note on Problems of Scientific Personnel* (1959), and *Recent Developments in the Organisation of Science in India* (1959), and also presented at the Conference for International Economic Cooperation and Partnership held in Austria (Salzburg-Vienna) in July 1962.

Professor P. M. S. Blackett in his presidential address to the British Association for the Advancement of Science in 1957 and in other articles in *Nature*, (3 February, 1962 ; May 1962 etc.) has considered various problems from the point of view of the advanced countries. Professor Stevan Dedijer made a penetrating analysis in an article in *Nature* (6 August, 1960) and in another article published in Stockholm, *TVF*, 33, (1962).

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RECENT DEVELOPMENTS IN THE ORGANIZATION OF SCIENCE IN INDIA

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INTRODUCTION

1. In the present article attention has been focussed on the institutional aspects of scientific work rather than on the scientific activities themselves. No attempt has been, therefore, made to review the progress of research as such; and only the broad lines of development have been indicated. It is worth recalling that significant advances had been made in ancient India in mathematics, astronomy, chemistry, medicine and certain branches of biology. From about the third century B.C. there were close contacts with Greeks and from the eighth or ninth centuries A.D. with the Arabs through which there was much exchange of scientific ideas and knowledge with the Middle East and Europe. The study of science and medicine continued with vigour during the period of Buddhist influence till the end of the 12th century. This was followed by a period of general stagnation relieved by some noteworthy investigations in chemistry and medicine during the Muslim period.

2. Scientific activities had, however, practically ceased at the time of the advent of the European nations in the 17th and 18th centuries. At this time there was a widespread system of education in the medium of the Sanskrit and the Persian languages, partly through schools of an institutional type but much more through instruction in private households which were open to children of other families. Surveys conducted in the 1830's in Bengal had indicated a literacy rate of the order of 5 or 6 per cent of the total population. The indigenous system of education was, however, highly scholastic in character with emphasis on grammatical and logical niceties; and was confined to a small section of the upper caste Hindus and upper class Muslims.

THE NINETEENTH CENTURY

3. With the growing influence of the British, the teaching of English had started for purely practical purposes. A great impetus was given to the teaching of English from about 1813 through the activities of Christian missionaries who opened modern schools in large numbers in different parts of the country. Some of the Indian leaders of thought like Ram Mohun Roy, with the active cooperation of David Hare and some other British residents, took the initiative in starting the Hindu College in Calcutta in 1817 as the first institution of a modern type in which education was given in English, history, geography, mathematics, elementary science etc. The standard in the senior class was broadly of university level. This institution was maintained from private sources till 1854 when it was taken over by Government and began to be called the Presidency College.

4. There was sharp controversy regarding educational policy. There were three distinct schools of opinion, one in favour of continuing the traditional system of education through Sanskrit, Persian and Arabic; another group was in favour of using the vernacular as the medium of instruction; and the third in favour of English as the medium of instruction and the modern system. It is interesting to recall in this connexion the position taken by Ram Mohun Roy who is known as the "father of modern India". He was a great

scholar of Sanskrit, Persian and Arabic; and later learnt English, Latin, Greek and Hebrew to study Hindu, Muslim and Christian scriptures in the original which made him a pioneer in comparative religion and the founder of a society of monotheists called the Brahmo Samaj. He attached much importance to the proper study of the Vedas and the ancient philosophical writings of the Hindus and had maintained a school for this purpose in Calcutta at his own expense. He was also a great pioneer in Bengali language and literature and published translations of many important Sanskrit books in Bengali and also started one of the earliest Bengali newspapers in Calcutta. He was thus both a classicist and a vernacularist in practice; and yet he fully appreciated the importance of Western science. In a remarkable letter dated 11 December 1823, addressed to Lord Amherst, the Governor General of India, he urged Government to employ "European gentlemen of talents and education to instruct the natives of India in Mathematics, Natural Philosophy, Chemistry, Anatomy and other useful sciences, which the Nations of Europe have carried to a degree of perfection that has raised them above the inhabitants of other parts of the world." He referred to the state of science and literature in Europe before the time of Lord Bacon and said, "If it had been intended to keep the British nation in ignorance of real knowledge the Baconian philosophy would not have been allowed to displace the system of the schoolmen, which was the best calculated to perpetuate ignorance. In the same manner the Sanskrit system of education would be best calculated to keep this country in darkness." He therefore advocated the teaching of science and pleaded for the establishment of "a college furnished with the necessary books, instruments and other apparatus."[1] His proposal, however, was not approved.

5. In the meantime the controversy about education continued; and after much discussion a final decision was made in 1835 in favour of English and the modern system of education. Looking back after an interval of more than a century, one can appreciate the cultural advantages of studying the classics, and also of the need of using the vernacular as the medium of instruction without which the promotion of universal education would be impossible. There was however an urgent need of introducing the teaching of modern science in India; and this was facilitated by the decision in favour of English education.

6. Serious study of the ancient and mediaeval literature of India started towards the end of the 18th century under the leadership of Sir William Jones who was a judge of the Surpreme Court. He was a great scholar of Sanskrit and founded the Asiatic Society of Bengal in 1784, and explained the objects of the enquiries to be "Man and Nature"; whatever is performed by the one, or produced by the other. This society during the first century of its existence provided a commodious house for meetings, library, collection of ancient coins and medals, and archaeological, technological, and geological collections and published 384 volumes of works of various kinds; and through its efforts the Indian Museum of Calcutta was founded in 1856. From about the middle of the nineteenth century the Asiatic Society started publishing papers on the positive sciences especially in zoology, botany and anthropometry with some papers on physics, meteorology, chemistry, geology and medical sciences and thus played a most important part in the advancement of science in India.

7. An Agricultural Society of India was established in Calcutta in 1820 and its name was changed to the Agricultural and Horticultural Society of India in 1823 which used to publish its transactions and journals for a long time. The Indian Association for

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[1] The English Works of Raja Ram Mohun Roy, Part IV, pp. 106-108 (Sadharan Brahmo Samaj, Calcutta, 1947).

the Cultivation of Science was founded and endowed in Calcutta in 1876 by Dr. Mahendra Lal Sircar. The Bombay Natural History Society was founded in 1883 which published a long series of journals from 1886; and has fostered a great deal of work in its own field. Other societies were established and were active from time to time.

8. After it was decided to adopt English education, an integrated system of primary and secondary schools was gradually built up. In 1837 English replaced Persian as the official language in the law courts. After much discussion, three Universities of a modern type were established in Calcutta, Bombay and Madras in 1857; and the Universities of Punjab (at Lahore) and of Allahabad were established in 1882 and 1887 respectively. All five universities were of the examining and affiliating type on the model of the London University; and up to the end of the nineteenth century there was no provision for teaching in the universities themselves. Science laboratories were established in some of the affiliated colleges, and towards the end of the century, research work had also started on a very small scale by some individual scientists.

9. Scientific services and agencies had also began to develop under Government. The British Army in India required medical care; and medical services were established in 1763. It was very expensive to bring all the medical personnel from Great Britain; and training began to be given to Indians to serve as auxiliary medical personnel; and a school was established for this purpose in Calcutta in 1822. One view was strongly in favour of continuing the training only of low grade personnel but the more liberal views prevented. One British medical officer (I believe, Richardson by name) wrote in a despatch that "once a candle is lighted it is not possible to say to its rays that they may go thus far and no further; in the same way, once the teaching of science was started, it was not possible to restrict it." After much controversy and discussions it was decided to establish the Calcutta Medical College in 1835 as a completely modern institution with provision for training in physics, chemistry, and botany in addition to anatomy and clinical subjects. The Grant Medical College was established in Bombay in 1845 and other medical colleges were gradually started in different parts of the country. Medical research was organized in 1869; and much valuable work was done on clinical medicine and the study of tropical diseases, of which an outstanding example was the identification of the anopheles mosquito as the vector of malaria by Sir Denison Ross. There were early publications on medicine in the transactions of the Medical and Physical Society (1825-1845) and a number of other medical journals were started and continued publication from time to time during the century.

10. Practical needs had also led to the establishment of a school for surveying in Madras in 1793. The Trigonometrical Survey of the Peninsula of India was established in 1800 and was expanded as the Great Trigonometrical Survey in 1818. Topographical and Revenue Surveys were consolidated in 1817, and were later amalgamated with the Trigonometrical Survey in 1878 to form the Survey of India which continues to function under this name at present. Outstanding work has been done by this organization which includes the measurement of the height of Mount Everest.

11. Some geologists had been employed for survey work since 1818 and the Geological Survey of India was founded in 1851 and continues to function under the same name. It has done very valuable work in geology but, as a matter of deliberate Government policy, all minerals prospecting was left to the private sector; and it is only very recently that emphasis is being given on such work.

12. A meteorological observatory had been started in 1796 at Madras, and meteorological stations were established in Calcutta in 1824 and in Bombay in 1841; and a Meteorological Department was established for the whole of India in 1875. The scientific foundations of Indian meteorology were established through the researches of this department. The Calcutta Botanical Garden was established in 1781 and the Botanical Survey of India was founded in Calcutta in 1889. Zoological and anthropometrical research had started in the Museum of the Asiatic Society in 1841 and was gradually strengthened with the foundation of the Indian Museum in 1856; these two sections were converted into the Zoological Survey of India in 1916. Some hydrographical work and important investigations on fisheries were also conducted from time to time. The Archaeological Department was established in 1862 and has done valuable work in building up the knowledge of Indian history.

13. Instruction in elementary engineering began to be provided for purely practical purposes in Bombay from 1824. An industrial school was started in Madras in 1840. The first engineering college of the modern type was established at Roorkee in 1947 and has been recently converted into an engineering university. Engineering colleges were also gradually established in Calcutta and other places. A big system of railways began to be built up from the 1850's but India continued to depend on imported coaches and locomotives for nearly a century. Large schemes for irrigation also began to be developed in the second half of the nineteenth century; and Indian achievements in this field have been outstanding.

14. At the end of the nineteenth century a good deal of scientific work was being done in the surveys and departments of Government which were closely connected with their operational activities. Some pure or basic research was also being done on a small scale, mostly in the field of sciences, in some of the private societies. Five universities had been established, but there was practically no provision for research. Also, there were practically no scientific institutes. Towards the end of the century, a few pioneering Indian scientists (for example, J. C. Bose in physics, P. C. Ray in chemistry) had started publishing papers in pure science. In many ways the ground had been prepared for new developments.

THE TWENTIETH CENTURY

15. Rapid advances took place in three main directions in the first half of the twentieth century. Firstly, there was a reorientation of university education with increasing facilities for postgraduate teaching and research. Secondly, research institutes of a specialized type began to be established both on private initiative and by Government. Thirdly, scientific societies of both a specialist and a general type began to be established for meetings and conferences and usually with their own journals and publications. These developments stimulated a great deal of research activities.

16. After fifty years of university education, the pattern began to change and provision for postgraduate teaching was made in the Calcutta University in 1909. Under the leadership of Asutosh Mookerjee, well-organized postgraduate departments were established for the first time, and the University College of Science was founded in Calcutta in 1917 with large endowments from Taraknath Palit and Rashbihary Ghosh. This gave a great impetus to scientific research and led to the establishment of research laboratories in other universities.

17. The first three universities had been founded in 1857, and two more were established in 30 years by 1887. There was no further expansion for nearly 30 years; but 14 new universities were established between 1916 and 1947, bringing the total number

to 19. University education had thus become fairly widespread just before independence. Many of the new universities were of the unitary and residential type and had some facilities for scientific research. Expansion was much more rapid since independence, and 15 new universities were established and 3 higher scientific institutions were given powers to award degrees in 10 or 11 years, by the end of 1958.

18. Another significant development was the emergence of both private and Government research institutes. The Indian Association for the Cultivation of Science, which had been founded in 1876, became a most important centre for physical research under leadership of C. V. Raman during the first world war. K. S. Krishnan and M. N. Saha were associated with this institution for a long time, and S. N. Bose is working there at present. The Indian Institute of Science was established in Bangalore in 1911 with generous financial support from Sir J. N. Tata and was developed as the first important higher institute of engineering and technology. The Bose Institute was established in Calcutta by Jagadish Chandra Bose in 1917 and has a wide programme of biophysical research. The Indian Statistical Institute was established in Calcutta in 1931 and has research and professional training activities in statistical and allied subjects. The Indian Academy of Sciences was founded by C. V. Raman at Bangalore in 1934 which later became a strong centre for physical research. The Tata Institute of Fundamental Research was started in Bombay in 1945 under the leadership of H. J. Bhabha and is now closely associated with the Atomic Energy Commission. The Institute of Palaeobotany was established at Lucknow in 1946 and has been now renamed after its founder Birbal Sahni. The Physical Research Laboratory was established in Ahmedabad in 1948 with financial support from the Sarabhai family. The Institute of Radio Physics and Electronics was established in Calcutta on the initiative of S. K. Mitra in 1949; and the Institute of Nuclear Physics was started in Calcutta on the initiative of Meghnad Saha in 1951. Two Cancer Research Institutes were started in Calcutta and in Bombay at about this time. The Shri Ram Institute of Industrial Research was established in Delhi in 1947 with endowments by Lala Shri Ram and was the first private institute of its kind. The Ahmedabad Textile Industry's Research Association was set up after independence as a joint endeavour of textile factories; and some other associations are being formed in the same pattern. These research institutions, which were started on private initiative, began to make significant contributions to the progress of science.

19. Specialized institutes had also began to be developed by Government especially in medicine and agriculture. The Haffkine Institute was established in Bombay in 1899, originally as a plague research laboratory, which gradually developed into an important centre of research of preventive medicine. The Central Research Institute for Medical Research was started at Kasauli in 1906 and one of its sections later developed into the Malaria Survey of India (1927). The Nutrition Research Institute at Coonoor was established in 1928 and the All-India Institute of Public Health and Hygiene in 1934. Other medical institutes were started by Provincial (now State) Governments, for example, King Institute of Preventive Medicine at Madras (1903), Pasteur Institute at Coonoor (1907), Medical Research Institute at Shillong (1917), the School of Tropical Medicine in Calcutta (1921).

20. In the field of agriculture, the Agricultural Research Institute was founded at Pusa in 1903 and was transferred to New Delhi after the severe earthquake in Bihar in 1934. Next came the Forest Research Institute at Dehra Dun (1906), the Tocklai Experimental Station in Assam for research on tea (1911), the Dairy Institute at Bangalore (1920), the Cotton Technological Institute in Bombay (1924), the Institute of Plant Industry at Indore

(1924), the Institute of Veterinary Research at Muktsar (1925), the Lac Research Institute at Ranchi (1925), Institute of Sugar Technology at Kanpur (1936), and the Jute Research Institute in Calcutta (1939). A number of research institutions also mostly in medicine and agriculture were established by the Provincial (now State) Governments.

21. Experimental work on river and irrigation problems had started after the first world war. Hydrological research laboratories were established in Sind, the Punjab, and the United Provinces by the Provincial Governments in the 1930's; and the Central Water and Power Research Station at Poona by the Central Government in 1937. Large developments in hydroelectric and irrigation projects had already started in India; and further progress was greatly helped by the research done in these laboratories.

22. Facilities for advanced studies and research in engineering (other than irrigation) however developed rather slowly. Departmental laboratories were set up by the Central Government for research on problems connected with railways, telegraphs, radio etc. The Indian Institute of Technology, the first higher institution with powers to award degrees, was established at Kharagpur in 1951, and similar institutes are being now started in different parts of the country.

23. With all these developments the need of co-ordination was increasing. A Board of Scientific Advice was established by the Central Government in 1902 which used to prepare annual reports on scientific progress; but it was not otherwise very effective and its activities were suspended in 1924. The Indian Research Fund Association was started in 1911 for the promotion of medical research and was later renamed the Indian Council of Medical Research (ICMR). The Indian Council of Agriculture Research was established in 1929, and has several associated committees for research in agricultural commodities (cotton, jute, sugarcane, oil seeds, tobacco, cocoanut, arecanut etc). The Council of Scientific and Industrial Research was started during the second world war; and, under the leadership of S. S. Bhatnagar, rapidly established a large number of National Laboratories and now has more than twenty institutions under its direct control.[1] All three Councils are, in legal form, non-Government corporations, but are under government audit and indirect government control. They function somewhat on the model of their three British counterparts in these fields, and give research grants to scientists.

24. Scientific societies mainly for meetings and conferences, and usually with journals and publications of their own, began to be formed about half a century ago. The Mining and Geological Institute of India was founded in 1906 and was followed by the Indian Mathematical Society (1907); Calcutta Mathematical Society (1908); Institution of Engineers, India (1920); Indian Botanical Society (1921); Indian Psycho-analytical Society (1922); Indian Chemical Society (1924); Geological, Mining and Metallurgical Society of India (1924); Indian Psychological Association (1925); Indian Statistical Institute (1931); Society of Biological Chemists (1931); Indian Physical Society (1934); Bio-chemical Society (1934); and the Indian Physiological Society (1935) before the second world war. Since then several other societies such as the Zoological Society, the Entomological Society, the Institute of Chemists, the Indian Council of Ecological Research, the Central Board of Geophysics and several

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[1] The National Physical Laboratory (New Delhi); National Chemical Laboratory (Poona); National Metallurgical Laboratory (Jamshedpur); National Botanical Gardens (Lucknow); Central Research Institute for Fuel Research (Jealgora); Glass & Ceramics (Calcutta); Food Technology (Mysore); Drug (Lucknow); Road (New Delhi); Leather (Madras); Electro-chemical (Karaikudi); Electronics Engineering (Pilani); Building (Roorkee); Salt (Bhavnagar); Mining (Dhanbad); Biochemistry and Medicine (Calcutta); Coal Survey (Dhanbad); two Regional Research Laboratories at Hyderabad and Jammu; and the Birla Industrial Technical Museum in Calcutta; and other units are being established.

geographical societies have been established, some of which have active programmes of research. In addition to societies which had an all-India character, a number of regional societies had also been started in different parts of the country before the second world war.[1]

25. Among associations of a general type covering many fields, the earliest was the Asiatic Society of Bengal which was founded in 1784. After an interval of 130 years the Indian Science Congress Association was established in 1914 and has been organizing annual sessions since then on the model of its British counterpart. A special feature since 1947 has been the presence of a large number of distinguished foreign scientists at its annual session. The United Province Academy of Sciences was started in North India in 1930 and was renamed the National Academy of Sciences in 1936. The Indian Academy of Sciences was established in 1934 originally as a general academy and became an active centre of research later on. Finally, the National Institute of Sciences was established in 1935, broadly on the model of the Royal Society of London, but in actual practice it functions in a somewhat different way. All these institutions have their own publications.

26. Two scientific weeklies, one, the "Current Science" somewhat on the model of the "Nature" of London, and the other, "Science and Culture", with a wider scope, were started between the two wars. A number of other scientific journals of a general type are also being published.

THE GENERAL PATTERN OF DEVELOPMENT

27. The general pattern of development is fairly clear. In the nineteenth century the trigonometrical and topographic surveys were quickly developed and medical services were organized very early by the British authorities to meet urgent requirements. There was rapid progress in civil engineering and irrigation. Geology also was developed fairly early to supply basic information required for the economic exploitation of minerals which however was left entirely to private industry. English education was accepted after much controversy, and led to the building up of a new system of education from the primary school to the university stage by the middle of the century. In more basic research, the initiative came from the Asiatic Society; and botanical, zoological and anthropological surveys began to be made on a fairly large scale. It was only towards the end of the nineteenth century that research work had started in laboratories.

28. In the first half of the twentieth century there was a great deal of expansion in research facilities in the universities; and many research institutes of a specialized type were established both on private initiative and by Government. In the private institutes and universities the most significant contributions, on the whole, were made in mathematical and physico-chemical subjects. The mathematical genius of Ramanujan was *sui generis*, which required the environment of the Cambridge University to bring it to fruition. The work of the other scientists, however, became possible only with the development of research facilities and with increasing social appreciation of research.

29. In the Government institutions the emphasis, up to the second world war, was on medicine and agriculture. This can be easily understood as there was very little progress of basic industries. The production of steel had started in 1908, on the initiative of Jamsedji Tata, but remained practically at the level of one million tons for fifty years

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[1] Specialist societies had also been established much earlier but they were mostly of a local character. For example, the Mysore Institute of Engineers was established in 1863 and the Anthropological Society of Bombay in 1886; and both still continue to function as local institutions. There were other such societies which were active from time to time.

although India has the biggest reserves of high quality iron ore in the whole world. Railways, textiles and some of the lighter industries were well developed but mostly with the help of imported machinery. It was only during the second world war, when imports were cut off, that attention began to be given to industrial production; and it was in response to urgent practical needs that the Council of Scientific and Industrial Research was established. At the time of independence, facilities for engineering and technological research were still extremely meagre; and research in biological subjects, on the whole, was not well developed.

PROGRESS SINCE INDEPENDENCE

30. India became independent in August 1947. And there was also partition which set up severe stresses and strains, both political and economic, some of which are still continuing. The former princely states were integrated; and state territories were reorganized more than once and the process has not yet been completed. Planning was accepted in 1951 as an indispensable tool for economic development; and socialism was accepted as the goal by the ruling Congress Party in 1954 and by the Indian Parliament in 1955. In the Second Five Year Plan, which began in 1956, great emphasis was given to industrialization. The production of steel is being increased from a level of one million tons to six million tons per year; and factories for heavy machineries, heavy electrical equipment, machine tools, oil, chemicals and many light industries are being established.

31. This has been a period of rapid changes in many directions. Fortunately, it has been also a period of steady expansion of education and scientific research. Between 1857 and 1947, that is, in ninety years before independence, 19 universities were established. During the first 11 or 12 years of independence, 15 new universities had been established and four higher educational institutions were empowered to award degrees. The University Grants Commission was established in 1956 on the British model; and has already made its influence felt in many ways for the promotion of science. There has also been a large increase in educational institutions of all types with a rapid increase, especially from the period of the Second Five Year Plan, in the number of scientific and technical personnel, and a great deal of expansion of facilities for research. A general statistical review is given below.

EDUCATIONAL INSTITUTIONS

32. The number of institutions of different types is shown in Table 1 in the Appendix for the three selected years, 1947-48 (the year of independence), 1951-52 (the beginning of the First Five Year Plan), and 1956-57 (the beginning of the Second Five Year Plan). The number of institutions, on the whole, had doubled in nine years between 1947-48 and 1956-57. That is, more educational institutions were established in these nine years than had been set up during the whole of the British period. The greatest increase had taken place in colleges for professional and technical education whose number increased three-fold.

33. There has been a rapid expansion of education at the stage of higher secondary schools, junior colleges, and universities. The number passing the "matriculation" examination (which qualifies for admission to universities and university-level institutions) was 116,680 in 1947-48; and increased to 429,494 in 1955-56, that is, was nearly four times higher in eight years. The number has been doubling in about four or five years since independence.

34. Enrolment and outturn at the intermediate and university levels are shown in Table 2 in the Appendix. Enrolment has, on the whole, nearly doubled in six years between

1950-51 and 1956-57. Outturn has increased by about 68 per cent; and the smaller increase is, of course, due to the lag between enrolment and passing an examination. By this time the outturn also must have doubled. There cannot be any doubt about the rapid expansion of education at college and university levels since independence.[1]

35. Out of the total enrolment, about 60 percent was at the intermediate level, 35 percent at the degree level, and a little over four per cent at the level of the master's degree. The proportions were roughly similar for the outturn. Science (including technology, medicine and agriculture) account for, out of all enrolments, only about a quarter at the intermediate level, an eighth at the degree level, and less than one and a half percent at the master's level. The share of science is thus only about 38 percent of all students at intermediate and university levels which is not satisfactory.

SCIENTIFIC AND TECHNICAL PERSONNEL

36. Progress of science may also be examined from the point of view of the increase in the number of scientific and technical personnel. We may first consider the case of "scientists". As the standard of science teaching at the degree level is believed to be somewhat low in India, it has been decided to define the term "scientist" as a person who possesses a master's degree in any of the branches of natural sciences (that is, mathematics or statistics, physics, chemistry, geology, botany and zoology) or a bachelor's degree in pharmaceutical or industrial chemistry or chemical technology.[2]

37. Data relating to the number of scientists turned out by Indian universities between 1910 and 1955 are given in Tables 3 and 4 in the Appendix. It would be seen that 31,880 scientists were turned out, as defined above, during a period of 47 years from 1910 to 1956. The average annual outturn of scientists was only 77 in the quinquennium 1910-1914 before the first world war, and had increased to 588 during 1933-39 just before the second world war. There was very little increase during the war, and progress was slow till 1949 or 1950. However, during the period of the First Five Year Plan, the number had more than doubled in five years from 1875 in 1951 to 3809 in 1956.

38. It is of interest to note that out of 31,880 scientists turned out between 1910 and 1956, less than half or 15,668 had come out upto 1947; and this must also have been about the same as the total outturn upto 1947 since the master's degree was introduced

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[1] It should be, however, pointed out that the expansion at the bottom has not been fully satisfactory. I have already mentioned that enquiries conducted in Bengal during the period 1835–1838 had indicated a literacy rate of the order of 5 or 6 percent of the population. This was based entirely on the indigenous system of education. With the gradual building up of a modern system of organized schools, education became accessible to a wider circle; but progress was slow. According to the successive Censuses of India, the number of literates per hundred was 4.8 in 1881, 5.8 in 1891, 5.3 in 1901, 5.9 in 1911, 7.2 in 1921, and 8.0 in 1931 (inclusive of Burma and Pakistan). Census data for 1941 were only partially tabulated and no estimates are available for literacy. The rate was 16.6 per hundred according to the Census of India in 1951, after partition. In 1956 the estimated rate was about 20 per hundred persons in 1956; but some recent sample surveys show a higher rate of the order of 22 or 23 per cent in the same year. It is clear that there has been an appreciable increase in literacy in recent years. Opportunities for education, especially at the secondary and higher levels, are however still available only for a comparatively small fraction of the total population. Special efforts are intended to be made in the Third Five Year Plan to expand primary education.

[2] In some Indian universities there are three-year courses for honours B.A. and B.Sc. degrees; these have been also included. That is, either three or four years of college education after the intermediate examination, or five or six years after the final examination in secondary schools or after the entrance examination for admission to a university, has been accepted as the basis of the above definition.

only in 1909. The number 16,218 coming out after independence, in nine years from 1948 to 1956, was thus greater than the total outturn during the whole period before independence.

39. The distribution between different subjects has remained remarkably steady; and it can be seen from the two bottom lines of Table 3 that the pattern during the whole period from 1910 to 1955 was very similar to that in the year 1955. In India, chemists and chemical technologists form nearly a third of all scientists; mathematicians, including statisticians, nearly a fourth; physicists a fifth; and botanists and zoologists less than a tenth each; with geologists only a little over a twentieth. I may, however, add that since 1955, great emphasis is being given to training in geology and the number of qualified geologists is increasing rapidly. This has been the direct result of a decision to expand the prospecting of minerals and geological investigations to promote the exploitation of domestic resources of minerals.

40. The outturn of engineers with degrees at the university level and with diplomas from engineering institutions is shown for quinquennial periods from 1915 to 1949 in Table 5 in the Appendix. More detailed figures are given for both enrolment and outturn of engineers for the period 1951-52 to 1958-59 in the next Table 6. The outturn of engineers had increased to some extent in the 1920's but slowed down during the economic recession of the 1930's and was somewhat stimulated by the increasing production in the 1940's during the war. Conditions continued to be more or less stationary after independence and during the period of the First Five Year Plan (1951-56). This was only natural because there was very little progress in industrial production during the First Five Year Plan.

41. There was, however, a complete change in outlook in the Second Five Year Plan (1956-61) in which great emphasis was placed on industrial development. The need of a large increase in the number of engineers and technologists was clearly appreciated and steps were taken to expand facilities for technical training. The effect can be seen from the rapid expansion of enrolment; this had increased by only about 25 percent upto 1954-55, but rose from 15,334 in 1955-56 to 31,018 in 1958-59 or more than doubled in three years. Admissions to degree level courses in engineering and technology increased from about 6,000 per year in 1955-56 to 11,000 in 1958-59, and are expected to rise to 13,000 in 1960-61.

42. Medical personnel is also receiving attention. The total number available in 1956 was estimated at about 71,600 qualified persons, of whom 38,400 were licentiates (with four year training) and the rest university level graduates. The licentiate (or four year) course was abolished after independence and all qualified medical personnel now receive university level training. The average rate of attrition has been estimated at about 2.5 percent per year out of which about 2 percent may be attributed to death and 0.5 per cent to retirement on account of old age. If the growth of population is about 1.8 or 2 per cent then an increase of the order of 4.5 per cent per year or at least 3,000 per year would be required to maintain the present availability of 176 qualified doctors per million persons.[1] It may be noted, however, that the distribution of qualified medical personnel is extremely uneven; and possibly only about one-tenth or one-eighth of all qualified persons reside in rural areas although the rural areas have roughly five times the urban population. The availability also varies very widely between the different States of India. It is intended to provide greater facilities for medical training, and to expand the health services during the Third Five Year Plan.

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[1] "Man-power Studies No. 15 : Doctors in India" (Perspective Planning Division, Planning Commission, New Delhi, August, 1959).

EXPANSION OF RESEARCH ACTIVITIES

43. The expansion of research activities can be seen from the budget of the three quasi-government research councils, the Indian Council of Agricultural Research (ICAR), the Indian Council of Medical Research (ICMR), and the Council of Scientific and Industrial Research (CSIR) which were all started before independence, and the Atomic Energy Commission which was started after independence and is a government agency. From the budget of these four organizations, given in Table 7 in the Appendix, it would be noticed that the total expenditure has gone up from about Rs. 11 million[1] in 1948-49 to about Rs. 134 million in 1959-60 showing an increase of over twelve times in eleven years. The budget expansion has been the biggest (nearly fourteen times) in ICAR, but a good deal of this expenditure is of a developmental rather than a research type. The increase in expenditure in ICMR for medical research of about seven times, and in CSIR for scientific and industrial research of about ten times, give some idea of the greater emphasis on research.[2]

THE PRESENT POSITION

44. Since independence there has also been a good deal of expansion of the normal activities of the scientific departments and institutes of Government such as the Survey of India, the Geological Survey, the Meteorological Department, the Indian Forest Research Institute, the Indian Agricultural Research Institute, the Indian Veterinary Research Institute, the Central Water and Power Board, and various other institutes, departmental laboratories, and research units under the Central and State Governments. The total expenditure on research may have increased seven or eight times. Government grants to the Universities and the private (non-government) scientific institutions have also been appreciably increased; but these still form a very small part of the total expenditure on research. This is not satisfactory.

45. In recent years systematic attention is being given to scientific and technical man-power for which separate agencies have been created in Government; and a Standing Committee of the Central Cabinet has been set up for Man-power. The world shortage of scientific and technical personnel has, however, created a special difficulty. A considerable number of able Indian scientists are now working abroad, mostly in the USA, usually because of the more attractive terms and conditions of service. This has led to a very curious situation. An advanced country like the USA, for example, have taken away some of the able Indian specialists and are sending American specialists in the same subject field to work in India under various schemes of technical aid. This is far more expensive and less effective. A more rational approach would be to help India to retain and make the best use of her own scientists.

NEED OF STRUCTURAL CHANGES

46. The organization of scientific and technical research took general shape in India during the British period. On the surface, the pattern of development was broadly the same as in the Western countries. There was a threefold structure: firstly, government agencies and institutes; secondly, universities and private scientific institutions; and, thirdly, private societies and associations primarily for meetings, conferences, and publications. In the highly industrialized countries of West Europe and America, the development of research

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[1] One Indian rupee = 0.21 U.S. cents approximately.

[2] The index number of wholesale prices with 1948 = 100, did not increase very much, and was about 110 or 115 in 1958 or 1959. As the salary of scientists had not increased, there was not much change in the cost structure; and expenditures in 1948-49 and in 1959-60 are broadly comparable.

had taken place mostly outside Government until the first world war in UK, and the second world war in other countries. In consequence, a durable structure of research had come into existence in the universities, scientific institutions, and industrial laboratories which were mostly financed from private sources. Sound scientific traditions with standards of criticism and evaluation were thus built up and were being maintained independently of Government.

47. In the socialist countries in Europe, before revolution, there was an older fabric of science broadly on the pattern of the countries of Western Europe. After revolution, all funds for research began to come from Government; and a very wise policy was adopted to establish autonomous Academies of Science and to make research agencies in universities and scientific institutions as free as possible from official control. This is also true of China. In the countries of both the Eastern and the Western blocks, scientists enjoy a great deal of autonomy.

48. The position in India is somewhat different. Most of the research expenditure is incurred in Government or quasi-government agencies. Very little or practically no research funds are available from private sources. The universities and private scientific institutions thus have to depend almost entirely on Government grants. There has not been enough time to build up a strong and independent tradition of scientific criticism and evaluation. The administrative machinery of Government continues to be highly centralized with a great deal of secretariat control in details, partly because the system was taken over from an alien Government and partly because of the lack of economic development. In this situation there are serious dangers of scientific progress being hampered by the pervasive pattern of hierarchical authorities. There is no difference of opinion about the urgent need of decentralization, but, in practice, progress has been very slow. It is possible that effective decentralization and lessening of bureaucratic control would come only with increasing economic maturity. But administrative rigidities may continue to hamper economic progress, while the lack (or a slow rate) of economic growth would tend to preserve such rigidities. This is one of the peculiar antinomies of the Indian situation.

49. It is not clear whether the Western structure of science is really suitable for Indian conditions. As in a political democracy, the form alone is not enough; without the proper content, the form itself may crumble. On the other hand, it is also not clear whether it is possible to establish in an effective way the structure of science which has been adopted in the socialist countries. A most urgent problem is to develop an organization of science suited to Indian needs.

HOPEFUL FEATURES

50. In India there is growing appreciation of the need of scientific progress. Expansion of scientific work has become more rapid from the period of the Second Five Year Plan when the intimate connexion between scientific progress and economic development began to be properly appreciated. In principle, it is now generally accepted that the programme of applied and developmental research should be directed towards the needs of national planning. It is also being appreciated that applied and developmental research must be based on fundamental research in which a great deal of freedom of choice of subjects and methods must be given to scientists to enable them to do their most fruitful work. Prime Minister Nehru has given a great lead by his personal association with scientific meetings and associations. Conditions are in many ways favourable for the progress of science but there are also internal weaknesses and dangers which can be overcome only through seriousness of purpose and integrity of thought and action on the part of the scientists themselves.

Appendix

TABLE 1. NUMBER OF EDUCATIONAL INSTITUTIONS IN INDIA BY TYPE WITH INDEX NUMBER OF INCREASE BETWEEN 1947–48 AND 1956–57

type of institution	number of institutions			index based on		
				1947-48 = 100		1951-52 = 100
	1947-48	1951-52	1956-57	1951-52	1956-57	1956-57
(1)	(2)	(3)	(4)	(5)	(6)	(7)
higher institutions						
1. universities	16	29	33	181	206	114
2. boards of education	5	9	12	180	240	133
3. research institutions	n.a.	20	41	—	—	205
4. arts & science colleges	459	552	773	120	168	140
5. sub-total (1)	480	610	859	127	179	141
colleges for professional and technical education						
6. agriculture	12	16	25	133	208	156
7. forestry	3	4	3	133	100	75
8. engineering	11	31	47	282	427	152
9. technology	6	4	7	67	117	175
10. medicine	24	42	99	175	413	236
11. veterinary science	5	10	14	20	280	140
12. education : training	38	55	133	145	350	242
13. physical education	—	7	10	—	—	143
14. commerce	18	22	28	122	156	127
15. law	15	22	29	147	193	132
16. others	—	1	4	—	—	400
17. sub-total (2)	132	214	399	162	302	186
colleges for special education						
18. music, dancing & fine arts	—	14	27	—	—	193
19. home science	—	2	—	—	—	—
20. oriental studies	—	49	79	—	—	161
21. sociology	—	3	6	—	—	200
22. others	—	—	10	—	—	—
23. sub-total (3)	—	68	122	—	—	179
24. total : higher education (4)	612	892	1,380	—	—	155

TABLE 1. NUMBER OF EDUCATIONAL INSTITUTIONS IN INDIA BY TYPE WITH INDEX NUMBER OF INCREASE BETWEEN 1947-48 AND 1956-57—*Continued*

type of institutions	number of institutions			index based on		
				1947-48 = 100		1951-52 = 100
	1947-48	1951-52	1956-57	1951-52	1956-57	1956-57
(1)	(2)	(3)	(4)	(5)	(6)	7
schools for general education						
25. high/higher secondary	4,076	8,063	11,805	198	290	146
26. middle	8,823	14,576	24,486	165	278	168
27. primary	140,794	215,036	287,298	160	204	134
28. pre-primary	—	330	769	—	—	233
29. sub-total (4)	153,693	238,005	324,358	155	211	136
schools for vocational and technical education						
30. agriculture	15	37	94	247	627	254
31. forestry	—	1	4	—	—	400
32. engineering	5	27	68	540	1,360	252
33. technical & industrial	504	427	644	85	128	151
34. medicine & vet. science	20	45	116	225	580	258
35. teacher's training	529	802	916	152	173	114
36. physical education	—	188	36	—	—	19
37. arts & crafts	15	352	304	2,347	2,027	86
38. commerce	302	583	829	193	274	142
39. others	—	1	11	—	—	1,100
40. sub-total (5)	1,390	2,463	3,022	177	217	123
schools for special education						
41. handicrafts	48	84	98	175	204	117
42. social work	—	14	44	—	—	314
43. music, dancing & fine arts	—	131	184	—	—	140
44. oriental studies	—	3,358	3,322	—	—	99
45. reformatory	13	21	37	162	285	176
46. social (adult education)	6,536	43,463	44,058	665	674	101
47. others	2,261	923	1,327	41	59	144
48. sub-total (6)	8,858	47,994	49,070	542	554	102
49. total : schools (7)	163,941	288,462	376,450	176	230	131
50. total recognised institutions	164,553	289,354	377,830	176	230	131
51. total un-recognised institutions	6,508	7,164	4,806	110	74	67
52. grand total (8)	171,061	296,518	382,636	173	224	129

Source : Ministry of Education, and Perspective Planning Division, Planning Commission.

TABLE 2. ENROLMENT AND OUTTURN OF TRAINEES IN INDIA BY SUBJECTS

	number enrolled (000)		1956-57	index number 1950-51 = 100	number passed		1955-56	index number 1950-51 = 100
	1950-51	1956-57	percentage		1950-51	1955-56	percentage	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
intermediate & diploma								
1. science	90.9	156.2	20.06	172	27,343	41,341	15.98	151
2. agriculture	1.6	6.1	0.78	381	673	1,245	0.48	185
3. engineering & technology	8.2	26.8	3.45	327	2,027	4,977	1.92	246
4. sub-total	100.7	189.1	24.29	188	30,043	47.563	18.38	158
5. arts & commerce	132.1	278.4	35.76	211	65,186	111,155	42.94	171
6. total intermediate & diploma	232.8	467.5	60.05	201	96,229	158,718	61.32	167
degree level								
7. science (pass)	31.5	54.4	6.99	173	10,407	14,947	5.78	144
8. science (honours)					786	1,209	0.57	154
9. engineering & technology	10.1	17.7	2.27	175	1,773	3,816	1.47	215
10. medicine & veterinary	15.3	24.0	3.08	157	1,923	3,074	1.19	160
11. agriculture	2.7	3.7	0.48	137	1,041	893	0.34	86
12. sub-total	59.6	99.8	12.82	167	15,930	23,939	9.25	150
13. arts & commerce	85.8	175.3	22.51	204	34,543	62,100	23.99	180
14. total degree level	145.4	275.1	35.33	189	50,473	86,039	33.24	170
master's degree								
15. science	4.7	8.2	1.05	174	1,398	2,539	0.98	182
16. engineering	0.2	0.6	0.08	300	88	148	0.06	168
17. medicine & veterinary	0.3	1.2	0.15	400	117	202	0.08	173
18. agriculture	0.4	0.6	0.08	150	143	152	0.06	106
19. sub-total	5.6	10.6	1.36	189	1,746	3,041	1.18	174
20. education	3.5	11.7	1.50	334	3,193	9,071	3.50	284
21. arts, commerce, law	12.2	13.7	1.76	112	3,584	1,974	0.76	55
22. total master's degree	31.3	36.0	4.62	169	8,523	14,086	5.44	165
23. grand total	399.5	778.6	100.00	195	154,225	258,843	100.00	168

Source : Perspective Planning Division, Planning Commission.

TABLE 3. NUMBER OF SCIENTISTS TURNED OUT BY INDIAN UNIVERSITIES : 1910- 955

	year	all subjects	number of degrees awarded in					
			mathematics	physics	geology	chemistry	botany	zoology
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.	1910–1955	28,947	7,533	5,897	1,552	8,669	2,497	2,799
2.	1910–1914	385	133	89	26	97	21	19
3.	1915–1919	832	391	220	25	112	48	36
4.	1920–1924	917	269	181	30	328	60	49
5.	1925–1929	1,923	516	399	47	449	245	267
6.	1930–1934	2,784	840	630	179	553	280	302
7.	1935–1939	2,938	819	647	183	739	264	286
8.	1940–1944	3,378	882	730	200	980	282	304
9.	1945–1949	4,375	1,074	800	294	1,588	294	225
10.	1950–1954	8,756	1,976	1,668	413	2,966	781	952
11.	1948	925	234	162	63	345	61	60
12.	1949	939	227	176	78	333	58	67
13.	1950	1,083	240	192	74	395	81	101
14.	1951	1,444	292	221	71	598	105	157
15.	1952	1,693	373	346	72	551	152	199
16.	1953	2,104	465	411	88	711	188	241
17.	1954	2,432	606	498	108	711	255	254
18.	1955	2,659	633	533	155	857	222	259
19.	percentage 1910–1955 = 100	100.0	26.0	20.4	5.4	29.9	8.6	9.7
20.	1955 = 100	100.0	23.9	20.0	5.8	32.2	8.4	9.7

TABLE 4. NUMBER AND ACCUMULATED TOTALS OF OUTTURN OF SCIENTISTS FROM INDIAN UNIVERSITIES : 1910–1956

	year	number of degrees awarded		index number 1910-14 = 100	accumulated total number col. (2)	percentage col. (5)
		total	average per year			
	(1)	(2)	(3)	(4)	(5)	(6)
1.	1910–1914	385	77	100	385	1.2
2.	1915–1919	832	166	216	1,217	3.8
3.	1920–1924	917	183	238	2,134	6.7
4.	1925–1929	1,923	385	500	4,057	12.7
5.	1930–1934	2,784	557	723	6,841	21.5
6.	1935–1939	2,938	588	764	9,779	30.7
7.	1940–1944	3,378	676	878	13,157	41.3
8.	1945	786	786	1,021	13,943	43.7
9.	1946	824	824	1,070	14,767	46.3
10.	1947	901	901	1,170	15,668	49.2
11.	1948	925	925	1,200	16,593	52.0
12.	1949	939	939	1,219	17,532	55.0
13.	1950	1,083	1,083	9,406	18,615	58.4
14.	1951	1,444	1,444	1,875	20,059	62.9
15.	1952	1,693	1,693	2,199	21,752	68.2
16.	1953	2,104	2,104	2,732	23,856	74.8
17.	1954	2,432	2,432	3,158	26,288	82.5
18.	1955	2,659	2,659	3,453	28,947	90.8
19.	1956	2,933	2,933	3,809	31,880	100.0

Source : "Man-power Studies No. 16 : Scientists in India" (Perspective Planning Division, Planning Commission, July 1959).

TABLE 5. OUTTURN OF DEGREE AND DIPLOMA HOLDERS IN ENGINEERING AND TECHNOLOGY IN INDIA : 1915–1951

	year	number		total	average annual outturn	index number 1915-19 = 100
		degree	diploma			
	(1)	(2)	(3)	(4)	(5)	(6)
1.	1915–1919	568	1,703	2,271	454	100
2.	1920–1924	771	1,902	2,673	535	118
3.	1925–1929	1,619	4,322	5,941	1,188	262
4.	1930–1934	2,190	5,397	7,587	1,517	334
5.	1935–1939	2,901	5,331	8,232	1,646	362
6.	1940–1944	3,765	6,280	10,045	2,009	442
7.	1945–1949	5,965	7,404	13,369	2,674	589
8.	1947–1948	1,251	1,393	2,644	2,644	582
9.	1948–1949	1,544	1,473	3,017	3,017	664
10.	1949–1950	1,896	1,757	3,653	3,653	804
11.	1950–1951	2,301	1,700	4,001	4,011	883

Source : Man-power Studies No. 5 : Engineers in India 1955 (Perspective Planning Division, Planning Commission, October 1957).

TABLE 6. NUMBER OF ENROLMENT AND OUTTURN OF DEGREE AND DIPLOMA HOLDERS IN ENGINEERING AND TECHNOLOGY IN INDIA : 1951–1959

	year	degree		diploma		total		index number 1951–52 = 100	
		intake	outturn	intake	outturn	intake	outturn	intake	outturn
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1.	1951–1952	4,788	2,693	6,216	2,626	11,004	5,319	100	100
2.	1952–1953	5,184	2,956	6,499	2,654	11,683	5,610	106	105
3.	1953–1954	5,450	2,880	7,213	2,747	12,663	5,627	115	106
4.	1954–1955	5,468	3,207	8,313	3,397	13,781	6,604	125	124
5.	1955–1956	5,037	4,017	9,397	4,072	15,334	8,089	139	152
6.	1956–1957	6,367	4,293	9,899	4,075	16,266	8,368	148	157
7.	1957–1958	9,778	4,290	15,995	5,034	25,773	9,324	234	175
8.	1958–1959	11,086	4,571	19,932	6,021	31,018	10,592	282	199

Source : Answer to question in the Parliament : Lok Sabha No. Education 21.7 on 10 August 1959.

TABLE 7. EXPENDITURE ON RESEARCH IN MILLION OF RUPEES AND INDEX NUMBER WITH 1948–49 = 100

year	ICMR	ICAR	CSIR	sub-total (2)+(3) +(4)	AEC current	total (5)+(6)	ICMR	ICAR	CSIR	sub-total col. (5)	total col. (7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	expenditure on research (in million rupees)						index number based on 1948-49 = 100				
1948–49	1.0	2.6	7.2	10.8	—	10.8	100	100	100	100	100
1949–50	1.2	2.3	11.2	14.7	—	14.7	120	888	156	136	136
1950–51	1.5	2.4	16.0	19.9	—	19.9	150	92	222	184	184
1951–52	1.3	3.9	17.8	23.0	—	23.0	130	150	247	213	214
1952–53	1.7	3.2	20.9	25.8	—	25.8	170	123	290	239	238
1953–54	1.5	5.1	19.8	26.4	—	26.4	150	196	275	244	244
1954–55	1.9	6.8	18.7	27.4	8.2	35.6	190	262	260	254	330
1955–56	2.9	6.5	22.7	32.1	15.2	47.3	290	250	315	297	439
1956–57	3.3	17.9	28.0	49.2	17.8	67.0	330	688	389	456	620
1957–58	5.7	23.7	35.5	64.9	23.8	88.7	570	912	493	601	821
1958–59	5.2	29.2	50.7	85.1	28.5	113.6	520	1123	704	788	1052
1959–60	7.2	35.0	61.5	103.7	30.0	133.7	720	1346	854	960	1238
total	34.4	138.6	310.0	483.0	123.5	606.5					

ICMR = Indian Council of Medical Research

CSIR = Council of Scientific & Industrial Research

ICAR = Indian Council of Agricultural Research

AEC = Atomic Energy Commission, current expenditure

Source : Central Statistical Office, Government of India.

BIBLIOGRAPHICAL NOTE

I have used a number of standard publications and may mention two books which give a good deal of information, namely, *The Progress of Science in India during the Past Twenty-five years* (Indian Science Congress Association, Calcutta, 1938); and *A History of Education in India* by Syed Nurullah and J. P. Naik (Macmillan & Co., second edition, 1957). I am grateful to the Central Statistical Organization, the Perspective Planning Division of the Planning Commission, and the Indian Statistical Institute for collecting and processing some of the statistical data.

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A STUDY OF CHILD HEALTH DURING THE FIRST YEAR OF LIFE

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SUMMARY. A survey of 560 in-patients of the maternity ward of R. G. Kar Medical College Hospital admitted in 1959–60 was conducted to study maternal and infant health conditions in the class of city population who usually seek hospital aid. Each patient was interviewed only once and the information collected at the time of interview supplemented by the information obtained from the hospital records provided the necessary data for this study. This paper deals only with the data relating to infant health such as infant mortality, morbidity and development and the factors associated with them. The data on maternal health conditions and the associated factors collected in this enquiry shall be dealt with in a subsequent paper.

1. Scope and coverage of the enquiry

Of late, there has been an increasing tendency among all sections of the city population to avail of modern methods of medical care. Hospitals are the only large institutions from which one can obtain medical treatment free of cost or for a nominal charge and bulk of the city population being extremely poor, seek hospital aid for its cheapness, if not for any other virtue. This is particularly true in the case of patients seeking obstetrical care. A striking feature observed in recent times among such cases is the rapid increase in the proportion of normal deliveries. This, however, does not imply that hospital admissions are representative of the general gravid population. Nevertheless, the authors are of the view that the hospital cases provide a very useful frame for the selection of a sample for the study of maternal and child health. The hospital records contain valuable information on conditions obtained during pregnancy and labour and type of operation performed. Besides these, the birthweight, gestation period and infant death occurring during the lying-in period are also recorded. Therefore, if a sample is selected judiciously from the hospital frame and information collected by a properly designed follow-up of the patients at their homes to supplement the information already available from the hospital records, the necessary data can be obtained to answer a variety of problems in the field of maternal and child health. The present study is in the nature of an exploratory one and was carried out on these lines, although precise results could not be presented, it is hoped that the experience obtained from this study may be of some guidance in future large-scale investigations.

This study is based on a survey of about 500 women who were admitted as in-patients in the labour wards of R. G. Kar Medical College Hospital, Calcutta in the year 1959-60. The annual admissions to the labour wards of this hospital had been steadily increasing in recent years and at present the total number admitted including abortion cases is about 4,000 a year. A sizeable proportion (31%) of the cases were drawn from the remote suburbs of Calcutta and most of those cases were unbooked. It is virtually impossible to send investigators all over the district to contact such cases. Further, these cases were mostly admitted on emergency grounds and as such cannot be considered as representative of the normal gravid population. Therefore, it was decided to exclude these cases from the coverage of this enquiry. Also, those cases with incomplete addresses had to be dropped for obvious reasons. For this study, therefore, the frame of reference for the selection of the sample had to be restricted to cases recorded in the hospital admission register with clearly identifiable Calcutta addresses. As a consequence of such a restriction a large proportion of the emergency cases have been excluded. What is left over for the selection of the sample is expected to be more approximate to the gravid population of such social classes as usually resort to hospital aid.

There is still another aspect in which hospital cases vary from the usual gravid population and that is in the inordinately large proportion of primi-gravida cases. In order, therefore, to bring the sample cases in conformity with the general gravid population, a smaller sampling fraction was adopted for the primi-gravida cases. The following table gives the percentage distribution by parity of cases (excluding abortions and still births) selected in the sample and in the reference frame described earlier.

TABLE 1. PERCENTAGE DISTRIBUTION OF CASES BY PARITY IN THE SAMPLE AND REFERENCE POPULATION

parity	percentage	
	sample	reference population
(1)	(2)	(3)
1	28.2	35.2
2	15.0	11.3
3	15.0	11.7
4	10.6	12.5
5	7.6	9.8
6 and above	23.6	19.5
	100.0	100.0

*Reference population comprises of all cases with Calcutta addresses excluding abortions and still births.

Still births and abortions were treated as a separate category in this study. The two main objectives of this enquiry were (a) to study the association between the post-natal complications as recorded by the investigators and the conditions prevailing during the ante-natal period and labour, and (b) to study the infant health conditions (morbidity, mortality and development) as revealed in the survey and its relation to birthweight (as recorded in the hospital) and social status, housing condition, maternal and infant diets etc. (as obtained by survey).

The first objective requires that mothers are contacted during or immediately after puerperium to ensure the accuracy of the reports on post-natal health conditions of the mothers. Further, as it is customary for daughters to go to their parents' home for their confinements and return to their husbands a few months after delivery, a large number of cases are likely to be lost if the enquiry is instituted long after the date of delivery. On the other hand, the second objective could be achieved satisfactorily only if for at least an adequate number of cases the contacts are established after the infants had a full year's exposure. This dual purpose could have been easily achieved if all the cases admitted in the year preceding the survey and included in the reference frame were covered by the enquiry. But in view of the limitations imposed by the resources at our disposal we resorted to the choice of a sample based on an optimum distribution of exposures. The following table shows the distribution of sample cases according to the time of contact for investigation.

TABLE 2. DISTRIBUTION OF CASES BY TIME OF CONTACT

time of contact (no. of months after delivery)	percentage of cases
(1)	(2)
upto 3.5	40
3.5–7.5	21
7.5-12.0	39

Also, it was essential for the purpose of obtaining reliable estimates of the association between post-natal complications and conditions prevailing during pregnancy and labour that some sort of stratification was effected at the very outset. For this purpose all cases for which the hospital records showed pregnancy complications and/or obstetrical complications and/or instrumental deliveries were grouped together into one stratum and the remaining cases, for which, no such abnormalities were recorded, were grouped together into another stratum and a smaller sampling fraction was adopted for the normal cases. The following table gives the proportion of normal cases in the sample and reference population by parity groups.

TABLE 3. PROPORTION OF NORMAL CASES IN EACH PARITY GROUP AMONG SAMPLE AND REFERENCE POPULATION

parity	percentage of normal cases	
	sample	reference population
(1)	(2)	(3)
1	29.1	30.3
2	52.7	76.2
3	62.7	64.4
4	62.3	75.3
5	52.9	78.1
6 and above	54.2	77.1
all parities	49.3	58.9

A number of patients who came from outside Calcutta had referred to some relatives' addresses within Calcutta, although they did not stay there after they were discharged from the hospital. Of the 670 patients with Calcutta addresses entered in the hospital admission register and selected for the survey 110 (16%) proved to be so when the male investigators attempted to contact them. These 110 cases were treated as outsiders and no attempt was made to collect any information regarding them. Again among the remaining 560 patients who stayed in the city after leaving the hospital, 121 left for their own homes before the male investigators could contact the households. In such cases, the male investigators merely obtained the information on the survival of the infants for the period of stay of the patients in the city or for such time as the informants could accurately report. The remaining 439 patients were found to be residing in the selected households at the time of the male investigators' visit. The investigators then secured the entire information required in the household schedule from the head of the household and fixed up an appointment for the subsequent visit of the nurse. Unfortunately, 17 of these patients left the household before the nurses could contact them for filling up the patient schedule. The following table gives the distribution of patients by the type of information collected.

TABLE 4. DISTRIBUTION OF PATIENTS BY TYPE OF INFORMATION COLLECTED

nature of termination	patients left		patients[3] present in both visits
	before[1]	after[2]	
(1)	(2)	(3)	(4)
abortions	9	0	33
still births	9	0	13
live births	106 (4 twin births)	17	376 (16 twins and 1 triplet)
all terminations	121	17	422[a]

[1] Male investigators: only infant survival known after.

[2] Male investigators visit but before nurses visit: only household schedule filled up.

[3] Information complete; both household and patient schedules filled up.

[a] Of the 422 cases, for which patient schedules were filled up, 35 (27 live births and 8 abortions) were rejected as the reliability of the information obtained by the nurses concerned was questionable. The field work of this nurse was discontinued.

2. METHOD OF ENQUIRY

This enquiry was conducted in two phases. In the first phase, male investigators contacted the selected households and enquired first, whether the patient stayed in the household after leaving the hospital and whether she was still staying in the household. If she has left the above household after staying for some time, the informant was asked to report about the survival of the child for the period over which he could furnish reliable information. In the majority of such cases, the informants were close relatives of the patient (father, brother, etc.) and were able to report the conditions up-to-date. In case frequent communications with the patient's family were lacking the survival of the infant only for the period of stay of the patient in the given address was noted. If the patient was continuing her stay in the same household at the time of the male investigator's visit, then the household schedule was filled up. This schedule furnished information about the age, sex, educational status, occupation, income etc. of all the members of the household (including the patient and the child). Further, the particulars about the migratory status of the household and housing conditions were also obtained. A facsimile of the household schedule is given in the appendix.

The second phase of investigation was carried out by interrogating the patients themselves. For this purpose six nurses were given intensive training by the medical adviser to this survey. Fortunately, these trained nurses could establish cordial relations with the patients which were helpful in eliciting the information required in the patient's schedule. The items of information entered in the patient's schedule have been broadly grouped as (a) amenorrhoea, lactation and new conceptions; (b) ante-natal and post-natal visits; (c) maternal and infant diet; (d) previous terminations and hospitalisation; (e) *maternal health*: (i) ante-natal complications are reported by the patients (hospital findings were entered separately after field enquiry); (ii) post-natal complications and medical care; (iii) chronic conditions; (f) *infant's health* : (i) birth weight and gestation period (entered from hospital records); (ii) survival and if dead, cause of death; (iii) morbidity and medical care; (iv) development (age in months at the time of dentation, sitting and standing).

A facsimile of the patient's schedule is also given in the appendix.

This study has been divided into two parts, one dealing with infant and the other with maternal health. In the present paper, the results presented are concerned with infant health only and those concerned with maternal conditions shall be dealt with in a subsequent paper.

3. INFANT HEALTH : STATISTICAL ANALYSIS AND RESULTS

The assessment of infant health has been made in terms of mortality, morbidity, physical and mental development. In this study morbidity has been assessed in terms of inception rates. Measurements of physical and mental growths have been made with respect to age at dentation and ages at sitting and standing respectively.

Infant mortality. Excluding abortions and still births altogether 499 patients have been included in this study. Some of these patients had plural births (20 twins and one triplet), thus making up the total live births followed up to 521.

The months of life completed by these infants at the time of visit varied very widely. Only about 17% of the infants had a full year's exposure. The distribution of the period after birth at which observations were made is given below :

TABLE 5. DISTRIBUTION OF LIVE BIRTHS BY TIME OF VISIT

time of visit (after delivery)	number of infants (surviving or dead)	time of visit (after delivery)	number of infants (surviving or dead)
(week)		(months)	
1	30	6	21
2	14	7	30
3	13	8	23
4	21	9	22
(months)		10	19
2	64	11	40
3	68	12	98
4	40		
5	18	total	521

If the infant was surviving at the time of visit, its exact exposure upto that date is known from the date of birth entered in the hospital records. If, however, the infant died, his age at death is entered in months by interrogating the mother. If the mother had left before she was contacted, the male investigator obtained the information of infant's survival upto a specified period from the household head.

The infant mortality rate adopted in this study is based on the actual exposures. Consequently, the statistical analysis became quite laborious when we attempted to relate the infant mortality to a variety of social and environmental factors. The line of analysis adopted is given below.

Line of analysis. Let n_i be the total number of contacts made between $(i-1)$-th and i-th month and of this let S_i be the number surviving at the time of visit and let d_{ij} $(j = 1, 2 \ldots i)$ be the number who died between $(j-1)$-th and j-th month. Each one among the S_i survivors contributed a unit exposure to each of the successive months $(0-1)$, $(1-2)$, and ... $[(i-2)-(i-1)]$ and a partial exposure in $[(i-1)-(i)]$ month. For the sake of simplicity the above partial exposure in $[(i-1)-i]$ month is regarded here as a unit exposure. Moreover, each one of the infants who died in $[(j-1)-j]$ month of life contributed a unit exposure in each of the successive months upto the month $[(j-1)-j]$. Further, each one of them is reckoned as a death in calculating the survival ratio from $(j-1)$-th to j-th month.

Summing up the exposures contributed by infants contacted at various periods we have the total exposure in month $[(k-1)-k]$ given by

$$E_{k-1,\,k} = \sum_{i=k}^{12} S_i + \sum_{i=k}^{12} \sum_{j=k}^{i} d_{ij}$$

and the total deaths in $[(k-1)-k]$ month given by

$$D_{k-1,\,k} = \sum_{i=k}^{12} d_{ik}$$

Thus the probability of survival from $[(k-1)]$-th to k-th month is given by

$$S_{k-1,\,k} = \frac{E_{k-1,\,k} - D_{k-1,\,k}}{E_{k-1,\,k}}$$

$$= \frac{\left[\sum\limits_{i=k}^{12} S_i + \sum\limits_{i=k}^{12} \sum\limits_{j=k}^{i} d_{ij} - \sum\limits_{i=k}^{12} d_{ik}\right]}{\sum\limits_{i=k}^{12} S_i + \sum\limits_{i=k}^{12} \sum\limits_{j=k}^{i} d_{ij}}$$

Calculating the successive survival ratios in this manner we obtain the probability of survival of the first year of life as the product $\prod\limits_{k=1}^{12} S_{k-1,\,k}$ and thus the infant mortality rate is given by $1000\left(1-\prod\limits_{k=1}^{12} S_{k-1,k}\right)$. This procedure has been adopted for all estimates of infant mortality rate discussed in the following paragraphs.

Causes of infant mortality. The new-born infant having survived the stresses of birth and made the sudden change from complete physiological dependence to an extra-uterine life now has to adopt itself to the stresses and strains that go with an independent existence. How far it succeeds in this struggle is partly determined by the factors of the external environment and partly by the child's inherent ability to cope with the antagonistic influence of such factors. A number of infants are so devitalised even at the time of birth that there is only a slender chance of their surviving the first few days of life even with the best care that can be bestowed. The birth of such weak babies are mostly ascribable to causes present before or during birth. The external environment cannot, of course, affect the foetus directly. But indirectly it affects the foetal development in a variety of ways and also brings about the termination of pregnancies before term. It has been shown in a number of studies conducted elsewhere that poor social conditions and poor physique and health among mothers are important predisposing factors of prematurity. Added to the extreme poverty and squalor that affect the overwhelming majority of the population in India, the utter lack of obstetrical and ante-natal facilities swell the number of premature and devitalised infants in this country.

Studies conducted in UK and other western countries have shown that deaths occurring in the first month of life are mostly ascribable to causes present before and during birth, (obstetrical causes), of which prematurity is the most important one. But deaths occurring at subsequent periods of the first year of life (post-neonatal deaths) are in the majority of cases ascribable to conditions present in the external environment. Overcrowding, inadequate child care, poor diet, insanitary conditions, lack of medical facilities and lack of health consciousness which characterise the poorer social classes are closely associated with the incidence of infectious diseases which take a heavy toll of infant lives in the post-neonatal period. Studies on time trends and contemporaneous differentials conducted in western countries have established beyond doubt the broad significance of the above factors in the variation of post-neonatal deaths.

The present study conducted by us also reveal that the majority of deaths in the neo-natal period are ascribable to causes present before or during birth, whereas those in the post-neonatal period are mostly caused by infections, malnutrition etc. In Table 6 the distribution of deaths by causes during neo-natal and post-neonatal periods obtained from our investigation is compared with that obtained for England and Wales by the Registrar General.

TABLE 6. NEO-NATAL AND POST-NEONATAL DEATH RATES PER 1000 LIVE BIRTHS BY CAUSES

neo-natal death rate				post-neo-natal death rate		
sl. no.	cause	present survey	England and Wales (1959)	cause	present survey	England and Wales (1959)
	all causes	100.00	15.8730	all causes	42.30	6,3433
	prematurity unqualified	28.85	3.6413	causes of prenatal or natal origin	0.00	1.8009
	birth injury with or without prematurity.	5.77	2.4698	pneumonia	2.82	1.9753
	asphyxia or atlectasis with or without prematurity	19.23	3.5879	diptheria	2.82	0.0000
	toxaemia and other maternal conditions with prematurity	3.85	0.1509	bronchitis	0.00	0.4911
	toxaemia and other maternal conditions without prematurity	3.85	0.0267	gastro-enteritis	11.28	0.3449
	congenital mal-formations	1.92	2.8425	dysentry	5.64	0.0054
	haemolytic diseases of newborn with or without prematurity	0.00	0.4742	other infections	2.82	0.4469
	haemorrhagic diseases of newborn with or without prematurity	0.00	0.2859	malnutrition	5.64	0.0094
	diarrhoea of the newborn with or without prematurity	3.85	0.0588	other specified diseases	2.82	0.7354
	pneumonia of the newborn with or without prematurity	3.85	1.0018	symptoms and illdefined conditions	5.64	0.0295
	illdefined diseases of newborn with or without prematurity	0.00	0.3887	accidents	0.00	0.5046
	other conditions with prematurity	0.00	0.1696	unknown	2.82	0.0000
	other infections	5.77	0.2004			
	other non-infectious diseases (specified)	0.00	0.4047			
	ymptoms and illde-fined conditions without prematurity	3.85	0.0174			
	accidents	5.77	0.1523			
	unknown	13.46	0.0000			

Despite the enormous difference in the absolute value of the rates between our series and that of England and Wales, there is a remarkable similarity in the distribution of deaths by causes.

The environmental factors operate jointly in a definite pattern set by the social circumstances and a precise assessment of the significance of each of these factors independently is beset with difficulties. An appropriate method of study in this situation should be to carry out the statistical analysis on the basis of multiple classification involving all the relevant variables. This was not possible in the present study because of the limited size of our sample. We had selected for this study only a few environmental factors which admitted precise classification of the subjects into markedly different categories and further no attempt was made to split the infant mortality rate into neo-natal and post-neonatal death rates. In the following paragraphs some of the important biological and environmental factors associated with infant mortality are discussed.

Prematurity. The hospital records give both the period of gestation and the birthweight of the infants. Since it is difficult to elicit accurate information about the period of gestation, particularly from illiterate patients, greater reliance is placed in this study on the birthweight, which is obtained by direct measurement. In an earlier study (Mukherjee and Biswas, 1959) it was shown that among 1038 patients of the R. G. Kar Medical College Hospital, who could precisely state the date of last menstrual period, the pregnancy was terminated before the 38th week in 30.5% cases and that among those the gestation period showed a remarkably close correspondence with birthweight. In view of the above finding and following the international convention we have adopted for this study the classification according to birthweight to represent different grades of maturity reached at the time of birth.

The 521 cases selected for this investigation comprised solely of those who stayed in the city after leaving the hospital whereas the general hospital population included, besides the city residents, a number of outsiders of whom a large proportion were unbooked cases. Further the sample included proportionately fewer primigravida cases. Consequently, the proportion of prematurely born infants in the sample was smaller despite the fact that abnormal cases were given additional weight in sample selection (a variety of complications have been taken into account for stratifying the cases as abnormal or normal and only a few of them are known to be predisposing factors of prematurity). The following table gives the distribution of infants by birth weight in the general hospital population and in the sample.

A few investigations into the causes of prematurity conducted in certain hospitals in UK (Grundy and Lewis-Fanning, 1951) have shown that in about half the cases prematurity could be attributed to obstetrical abnormalities of which the most important are maternal toxaemia and haemorrhage (25%), multiple pregnancy (20%) and congenital malformations (5%). In the remaining half no satisfactory causes could be found; the pregnancy was clinically normal and either an unexpectedly small

TABLE 7. PERCENAGE DISTRIBUTION OF INFANTS BY BIRTHWEIGHT

birthweight (in lbs.)	general hospital population (percentage)	sample selected for this investigation (percentage)
(1)	(2)	(3)
1—2	2.02	0.38
2—3	1.00	1.15
3—4	3.13	1.34
4—5	10.02	3.64
5—6	32.26	16.86
6—7	36.21	33.52
7—8	12.59	28.74
8 and above	2.76	14.37

baby was born or labour started prematurely for no obvious reasons. In our study quite a number of babies were born after full term, although their birthweights were low. In about half the cases the pregnancies were normal. The incidence of prematurity was appreciably high among multiple pregnancies and among cases in which ante-partum haemorrhage (accidental haemorrhage, placenta previa, threatened abortions etc.) were reported. Curiously enough the incidence of prematurity among pre-eclamptic toxaemia cases was low.

TABLE 8. ASSOCIATION OF PREMATURITY WITH PREGNANCY COMPLICATION

conditions present before birth		premature infants[1]		mature infants[2]	
		number	percent	number	percent
(1)		(2)	(3)	(4)	(5)
A	pre-eclamptic toaxemia, eclampsia, hypertension	2	5.9	42	8.6
B	multiple pregnancy	9	26.5	28	5.7
C	multiple pregnancy with A	3	8.8	3	0.6
D	haemorrhage (antepurtum and threatened abortions)	3	8.8	17	3.5
E	cases without any of the above conditions	17	50.0	397	81.5
		34	100.0	487	99.9

[1] Birthweight below 5 lbs.

[2] Birthweight 5 lbs or higher.

These results, being based on a very small sample, should be accepted only with reservation. But a common feature which is revealed by both these investigations, the one conducted in UK and the present one, is that about half the cases of prematurity arises from unexplained causes and it is mainly these that are shown up in the social class differentials. Mukherjee and Biswas (1959) have pointed out in their investigation that there were striking differentials in the incidence of prematurity at low gestation periods between patients admitted in paying and non-paying wards, the former including a greater proportion of those who could afford to pay. Marked differentials in the incidence of prematurity (premature infant being defined as one having birthweight less than 5½ lbs) have also been observed among social classes in Great Britain.

TABLE 9. INCIDENCE OF PREMATURITY BY SOCIAL CLASSES IN GREAT BRITAIN (Grundy and Lewis-Fanning)

	social class				
	1 and 2	3	4	5	all classes
	(1)	(2)	(3)	(4)	(5)
rate per 100 live births	5.3	6.3	7.5	8.3	6.5

In our study also a striking social class gradient in the incidence of prematurity was observed. Table 10 gives the percentage distribution of infants by birthweight in each of the following three social classes: I : (a) father matriculate or above (b) family income greater than or equal to Rs. 200 ; II : only one of the conditions in (a), (b) in I is satisfied; III : (a) father below matric, (b) family income less than Rs. 200.

TABLE 10. INCIDENCE OF PREMATURITY BY SOCIAL CLASSES (present survey)

	social class					
	I		II		III	
birthweight (in lbs.)	no. of infants	percentage	no. of infants	percentage	no. of infants	percentage
(1)	(2)	(3)	(4)	(5)	(6)	(7)
less than 5	4	3.54	9	6.24	15	9.74
greater or equal to 5	109	96.46	135	93.74	139	90.26
total	113	100.00	144	100.00	154	100.00

On a more detailed analysis of the above data it was found that the housing conditions, standards of maternal care and a number of other factors which are implied by the social position of the patients are closely associated with the incidence of prematurity.

Standards of maturity. Many prematurely born infants are blighted within a few days or even hours after birth and consequently prematurity is the major factor to be considered in interpreting social class differentials in neo-natal mortality. Since the premature infants require special care and environment for their survival it is quite important to draw a line of demarcation between premature and functionally mature infants. In western countries the definition adopted is based on birthweight, a child having a birthweight less than 5½ lbs being considered as premature. The definition based on birthweight may not be entirely satisfactory since a few babies with birthweight below 5½ lbs might have attained functional maturity. The average weight of babies delivered in Indian hospitals is only 6 lbs. A large number of full term babies delivered in those hospitals have low birthweights and yet show practically no characteristics of functional immaturity. It is therefore pertinent to enquire as to what should be adopted as the criterion for the definition of prematurity in the circumstances obtained here at present. For this purpose it seems desirable that the definition of prematurity must take fully into consideration the chance of survival of infants when no special care has been bestowed on it. Most of the patients included in our enquiry belong to the poorest social class in this city. It is hardly possible for them to give any extra attention to their infants even if they be immature. Also, no additional medical care is possible within hospitals for reasons well known. It can, therefore, be expected that the mortality rates among the premature infants obtained at present reflect more truly their chance of survival in uncontrolled conditions. Table 11 gives the infant mortality rates by birthweight

TABLE 11. INFANT MORTALITY RATES BY BIRTHWEIGHT

birthweight (in lbs.)	number of infants in the sample	probability of surviving the 1st year of life	infant mortality rate per 1000 live births
(1)	(2)	(3)	(4)
1–2	2	0.0000	1000.0
2–3	6	0.0000	1000.0
3–4	7	0.0000	1000.0
4–5	19	0.3684	631.6
5–6	88	0.7837	216.3
6–7	175	0.9110	89.0
7–8	150	0.9247	75.3
8 and above	74	1.0000	0.0
total	521	0.8577	142.3

The level of mortality falls abruptly after the birthweight has reached the critical level of 5 lbs. It was desirable to analyse the mortality rates by finer intervals of birthweight around the level of 5 lbs to obtain more precisely the turning point at which hazards peculiar to prematurity ceases. But this was not possible in this study due to the inadequate size of the sample. If the level of 5 lbs is applied, 6.51% of the infants selected in the survey will be classified as prematures, whereas by the western standard of 5½ lbs, 16.09% of the infants will be classified as premature.

When the wherewithal for the care of the really premature infants is itself very doubtful in this country, there is no virtue in swelling the number of prematures by adopting standards which are too high for this population.

In Section 1 it was pointed out that the general hospital population included a large number of unbooked cases, mostly arriving from distant suburbs of the city and seeking admission on emergency grounds and thus swelling the proportion of premature infants. The reference population (those with Calcutta addresses) too had a considerably higher proportion of prematures, although for a different reason, namely, the greater inclusion of primi-gravida cases. If, therefore, we were to apply the survival rates of the birthweight classes as in Table 11 on the general hospital population we may be obtaining considerably higher infant mortality rates than the one observed in the survey sample. In fact the application of the above survival rates gave for the birthweight distribution of the general hospital population and the reference population infant mortality rates of 236.3 and 197.3 respectively.

Parity. Maternal age and parity have long been considered as important biological factors affecting still birth and infant mortality rates. It has been observed that the still birth rates rise steeply with maternal age at each parity and also that they are higher for primi-gravida than for other parities. Physiological deterioration of maternal tissues is considerably mitigated by the influence of parity and since age and parity rise together, the resultant variation in foetal mortality over parities is often distorted by maternal age. In the case of post-neonatal death rates, however, the direct influence of maternal age and parity on the vitality of the infants has become weak and environmental causes now predominate. Women with fewer children can give better care to their imfants and this explains to a great extent the rise in post-neonatal mortality rates with parity. This variation has little to do with parity as a biological characteristic. In the case of neo-natal mortality rates the pattern of variation over parities is intermediate between those of still birth and post-neonatal mortality rates, because both obstetric and environmental causes directly affect neo-natal mortality rates. It has been observed in an investigation conducted by Mckeown and Gibson (1951) that the incidence of prematurity was highest among first born babies, was somewhat low for the next two parities and was again high for the fourth and higher parities.

TABLE 12. INCIDENCE OF PREMATURITY BY BIRTH ORDER
(Mckeown and Gibson)

birth order	1	2	3	4 and above
	(1)	(2)	(3)	(4)
percent premature	7.04	5.64	4.87	6.16

In an earlier section we had observed that prematurity and associated causes account for a substantial proportion of neo-natal deaths and their origin is partly biological and partly environmental. Taking neo-natal and post-neonatal death rates together (the infant mortality rate) we may observe that both biological and social factors are of significance but when the purpose is to study parity as a biological characteristic it is essential to disentangle it from social class variation.

An attempt on these lines was made in one of our earlier investigations (Poti, Raman, Biswas and Chakravorti, 1959) in which only those women who had at least 5 pregnancy terminations were considered. In this analysis the question of social selection did not arise because the bases for successive birth orders were represented by the same set of women. However, in the present context the significance of secular trend cannot be overlooked, the birth of higher parities being more or less very recent events might have obtained better medical attention.

TABLE 13. INFANT MORTALITY RATES BY BIRTH ORDER
(Pilot health survey in West Bengal—1955)

birth order	infant mortality rates rural	per 1000 live births urban
(1)	(2)	(3)
1	244.00 (500)	205.13 (156)
2	228.00 (500)	202.53 (158)
3	198.02 (505)	121.02 (157)
4	157.37 (502)	132.08 (159)
5	134.92 (504)	87.50 (160)
6	118.13 (364)	123.81 (105)
7	101.21 (247)	51.28 (78)
8 and above	96.67 (300)	148.15 (100)

Note: Figures in parenthesis refer to the number of infants. Slight inequality in these numbers upto para 5 is due to the incidence of still births and multiple pregnancies. Because the criterion for inclusion in the analysis was that the mothers should be at least of the 5th para, the numbers decrease after the 5th.

Both in the urban and rural populations a systematic decline in infant mortality rate with rise in parity can be observed from the above table. In the present investigation also a general tendency for infant mortality rates to decrease with parity has been noticed. However, a deviation was observed in parities 4 and 5 in which a higher infant mortality rate was observed. Since this investigation relates to the hospital population, who are mostly drawn from poor social classes, a striking variation in social class composition among the parities was not expected. However, there is a certain amount of variation among the parents with respect to their education and ability to obtain medical care in times of need. It is, therefore, pertinent to examine, how far the birth order differentials obtained in this study, could be ascribed to social class variation.

The figures shown in Table 14 clearly indicate that the deviation observed in parities 4 and 5 could be ascribed to the higher proportion of lower social class subjects included in them.

TABLE 14. INFANT MORTALITY RATE BY BIRTH ORDER

(present survey)

birth order	social class composition (in %)			infant mortality rate per 1000 live births
	I	II	III	
(1)	(2)	(3)	(4)	(5)
1	26	44	30	151.5
2 and 3	31	34	35	136.6
4 and 5	22	26	52	148.6
6 and above	29	35	36	124.2

In this analysis the question of secular trend does not arise because all the births considered had occurred in the same year. As stated earlier the quality of infant care is usually better in the case of families with fewer children. If this has any significant influence on infant mortality we should expect an increase in mortality with rise in parity. On the other hand, the present investigation indicates a reverse trend in infant mortality rates, thus providing a clue to certain vital factors associated with birth order. The primi-parous women admitted to the hospitals are of very tender age and the collected evidence clearly indicates that the foetal vitality in respect of these cases is inordinately low.

Housing. It was shown in an earlier section that about 60% of the post-neonatal deaths are caused by infections and since movements of infants are usually restricted such infections must have been originated from within the dwelling place itself, or from its immediate neighbourhood. Insanitary conditions and overcrowding are, therefore, considered as important factors contributing to infant deaths, particularly in the post-neonatal period.

Since low social status and poor housing go hand in hand numerous other environmental factors like poor diet, lack of care, etc, associated with the former get entangled with the latter. Mortality differentials with respect to standard of housing cannot, therefore, be wholly ascribed to sanitary conditions. Detailed study on the morbid conditions resulting from infections can possibly throw some light for an assessment of the effect of these latter factors on infant health.

In the conditions obtained now, overcrowding is almost universal among the lower strata of society to which most of subjects of this enquiry belong. Hence no useful purpose is likely to be served by collecting information on this point. However, we observed a wide range of variation in the sanitary conditions, in respect of 3 items of sanitary amenities availed of by the families, namely, (a) source of water supply (b) toilet and (c) bathroom. Based on these criteria two distinct groups could be formed. The first one comprised of families who had separate arrangements for all the three facilities and the second one comprised of those who shared all the three facilities with other families living within the premises. Besides these two major groups there were a number of very small groups of families who had arrangements for one or two facilities exclusively for themselves and in respect of the other facilities had to share with other families within the premises or even resort to municipal taps, toilets, etc. For the purpose of this analysis these small groups have been amalgamated with one or the other of the two major groups mentioned above on the basis of rental value of the dwelling place. Infant mortality rates relating to these two groups are worked out and shown in Table 15. The increase in mortality with the lack of essential sanitary amenities is quite evident from the figures given in the table.

TABLE 15. INFANT MORTALITY BY HOUSING STANDARDS

housing standard	number of infants	infant mortality rate per 1000 live births
(1)	(2)	(3)
(a) sanitary facilities adequate	136	110.8
(b) sanitary facilities inadequate	275	146.0

Maternal diet. Several nutritional investigations have been conducted to assess the effect of maternal diet on foetal development. Tidsall (1945) and others have obtained interesting results from their study of the effect of pre-natal diet on duration of labour, infant morbidity and mortality. From among two groups of women coming to a pre-natal clinic and both on poor diet and identical as far as nutritional intake is concerned, one was selected and given specified quantities of supplementary items like eggs, milk, cheese etc. and the other was maintained without any of these supplements during the period of pregnancy. It was observed that the duration of labour was considerably reduced in the case of the group on supplementary diet, by about 25% and 15% among primipara and multipara respectively. In respect of infant morbidity also there was striking improvement. The incidence rates in a 6-month period in the supplementary diet group were pneumonia (1.5%), bronchitis (1.5%), tetany (0.0%), rickets (0.0%) and anaemia (9.4%), whereas in the control group, they were 5.5%, 4.2%, 4.2%, 5.5% and 25.0% in the same order. There were no miscarriages, still births or infant deaths in the supplementary diet group. On the other hand, in the control group 9% resulted either in miscarriage or in still birth and $2\frac{1}{2}$% in infant death. In another study Burke (1942) stated that the birthweights of the infants were observed to steadily rise with protein intake during the pre-natal period.

In the present investigation since almost all the subjects were on a poor diet normally the emphasis was laid on specific additions made during the pre-natal period to the normal diet of the patient rather than on the total quantities consumed. If the patient reported to the nurse investigator that her intake of food was supplemented by at least moderate quantities of fish, milk, eggs etc. during pregnancy, her pre-natal diet was rated as A (adequate) and in case no such additions were made her diet was rated as B (inadequate). How birthweight varied with the standard of pre-natal diet is shown in the table below.

TABLE 16. DISTRIBUTION OF BIRTHWEIGHT BY STANDARDS OF PRE-NATAL DIET

I. average birthweight according to daily intake of proteins during pre-natal period (Burke's data)

sex of the infants	average daily intake of protein in grams					
	less than 45	45–54	55–64	65–74	75–84	85–above
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	birthweight in pounds and ounces					
boys	7– 8	7– 0	7– 7	8– 0	8–5	9– 2
girls	5–14	6–14	7– 8	7–12	8–1	8– 8

II. distribution of infants by birthweight in two pre-natal diet groups (present study)

pre-natal diet groups	birthweight in lbs				
	5	5—6	6—7	7 and above	total
(1)	(2)	(3)	(4)	(5)	(6)
A adequate	3 (2.5%)	23 (19.2%)	42 (38.1%)	52 (43.3%)	120 (100%)
B inadequate	23 (9.7%)	69 (29.2%)	90 (38.1%)	54 (22.9%)	236 (99.9%)

One in ten of the infants born to women in poor pre-natal diet group were premature (brithweights less than 5 lbs) compared to one in forty among those born in adequate pre-natal diet group. In the former group even the marginal class 5-6 lbs is represented in considerably larger proportion.

In the previous section we had observed a systematic increase in infant mortality with decrease in birthweight. One should, therefore, expect a considerably higher infant mortality rate among infants in the inadequate pre-natal diet group. The results given in Table 17, no doubt, support this view.

TABLE 17. INFANT MORTALITY RATE BY PRE-NATAL DIET GROUPS

prenatal diet group	number of infants	infant mortality rate per 1000 live births
(1)	(2)	(3)
A adequate	120	79.6
B inadequate	236	129.6

Ante-natal care. The number of visits made by the patients during the ante-natal period either to private physicians or to hospitals, the purpose and time of such visits etc. were reported by the patients to the nurse investigators. Considering the low level of health consciousness among the subjects it was quite surprising to observe that the overwhelming majority of them had made at least one visit. A few among those who visited the hospital only once did so for the purpose of consultations prior to obtaining admission. But even after excluding such cases a large majority of the patients were reported to have visited at early statges of pregnancy and quite frequently. However, on a detailed examination of these cases, it was observed that most of the patients had visited the clinics for treatment of some severe maladies from which they were suffering and only very few of the visits were undertaken as a routine preventive measure. Consequently, the group of women reported to have made 'adequate' number of ante-natal visits tended to include a large proportion of complicated cases which partly explains the observed tendency for the infant mortality to rise with the frequency of ante-natal visits.

TABLE 18. INFANT MORTALITY RATE BY ADEQUACY OF ANTE-NATAL VISITS

ante-natal visit (1)	number of infants (2)	infant mortality rate per 1000 live births (3)
group A at least one visit before the 4th month and one after the 7th month of pregnancy	68	131.5
group B one or more visits not distributed as in group A	181	113.1
group C no visits made or visited just once in connexion with admission to this hospital	107	78.6

Social class. Standards of housing and sanitation, maternal diet, and infant care, the wherewithal to procure timely medical aid and numerous other characteristics are implied by the term 'way of living'. The problem of finding a unique criterion to account for the variations and mutual interactions of such factors is indeed complex. However, attempts have been made in many earlier studies to adopt the criterion of social status defined in an appropriate way to represent some aspects of the 'way of living', particularly those concerned with variations in infant mortality. In this connexion it may be appropriate to mention a few of the important results obtained in a national survey conducted in Great Britain in 1948 [Douglas and others, (1949), (1951-52)]. The main objective of this was to assess the social class differences in infant health and survival. The social classification adopted was the one followed in the family census, based on the occupational status of the parents. The rise in post-neonatal (1—12 months) deaths with lowering of social status was indeed striking. Incidence of infections during this period showed a steep social class gradient and both in respect of untreated cases and case fatality, the manual workers class showed considerably higher ratios. In the case of neo-natal mortality rates also striking differentials were observed. Approximately half of the neo-natal deaths occur among premature births and as stated in an earlier section the incidence of prematurity falls steeply with rise in social status. The authors of the above study have shown that after excluding premature infants the social class differences in neo-natal mortality rates are considerably reduced. The following table gives the infant mortality rates by social classes before and after exclusion of premature infants.

TABLE 19. MONTHLY DEATH RATES PER 100 SURVIVORS BY AGE AND SOCIAL CLASS
(Douglas, 1948)

birthweight class	infants age (in months)	professional and salaried	blackcoated	manual workers	agricultural workers
(1)	(2)	(3)	(4)	(5)	(6)
all birthweights	(1 or less)	16.89	23.34	25.83	27.30
	1—12	0.62	0.68	1.81	1.36
birthweight over 5½ lbs	(1 or less)	8.76	10.06	12.62	11.33
	1—12	0.64	0.65	1.65	1.06

In our investigation the social classification was based on two criteria, namely, family income and education of fathers as follows :

Social class. high : father matriculate or above and income equal to or higher than Rs. 200 per month; middle : (a) father matriculate or above but income less than Rs. 200 per month or (b) father's education below matriculation but income equals or exceeds Rs. 200 per month; low : father's education below matriculation and income less than Rs. 200 per month.

In this classification the 'middle' group is somewhat heterogeneous, some of the subjects being in close proximity to 'high' and others to 'low' social classes. But this leaves each of the two extreme groups 'high' and 'low' homogeneous and distinct from each other. In Table 10 we had shown that the incidence of prematurity increased systematically with lowering of social status. Also, in the case of sickness inception rates which shall be dealt with in a later section, a steep gradient is discernible. In view of these, infants belonging to the lower social classes are exposed to a considerably higher risk than those in the higher classes as is seen from the table below.

TABLE 20. . SOCIAL CLASS VARIATION IN INFANT MORTALITY RATES

social class	number of infants	infant mortality rate per 1000 live births
(1)	(2)	(3)
high	113	79.7
middle	144	130.7
low	154	174.7

Infant morbidity. In this enquiry information on infant morbidity was obtained by the nurse investigators only if the infant was surviving on the date of visit. If the child was dead, the investigator was merely required to note the cause of death and age at death. As stated in the earlier section, each patient was visited only once and the age of the child at the time of contact varied widely. For instance, out of 365 infants for whom information on morbidity has been collected 128 or 35% were contacted at the tenth month or later and 109 infants or 30% were contacted at the third month or earlier. The total exposure of the former group was 1517 months and 132 cases of illnesses were reported, yielding an inception rate of 9 cases per 100 months whereas among the 109 infants of the latter group who were exposed for a period of 245 months, 73 cases were reported, yielding an inception rate of 30 cases per 100 months. The former group of children had certainly undergone the initial stages of life as those in the latter group and further they had been exposed for more than 1000 months after the third month of life and yet the total number of cases reported in the former group only slightly exceeded the number that one should have expected if they had been contacted before the third month as was done for the latter group. Obviously we have to infer that the mothers contacted at later stages must have failed to recall many cases of minor illnesses of their children which occurred in early infancy.

In this study the first year of infant life was divided into critical intervals (0—1 week), (1 week—1 month), (1 month—3 months), (3—6 months) and (6—12 months) and each mother was asked to report the onset of any diseases suffered by her infant by successive intervals as above. This procedure helped the respondents to some extent in recalling past illnesses and place the point of onset in broad age intervals. In case the infant was dead, the incidence of the morbid conditions preceding the death was allocated to the appropriate age interval. The cause of illness and medical care availed of were recorded in exactly the same form as reported by the mothers. Nomenclature and classification codes were inserted later in the office. A number of cases reported in this survey were mere symptons like fever, cold or cough. If in such cases no medical care was availed, they were ignored. There were 33 such cases.

The following table gives the inception rates for all causes of morbidity combined by critical periods of infant life.

TABLE 21. INCEPTION RATES (NUMBER OF CASES/100 MONTHS OF EXPOSURE) BY AGE PERIODS—ALL CAUSES OF MORBIDITY COMBINED

age period (in months) (1)	exposure in months (2)	number of cases (3)	inception rate (4)
0— 1	353	82	23.23
1— 3	648	72	11.11
3— 6	694	79	11.38
6—12	875	84	9.60
total	2570	317	12.33

The inception rate for the first month of life is nearly double the average rate for the year. If under-reporting due to memory lapse had affected these rates, it is the rate for the first month which should have been affected most because all the infants irrespective of their ages at which they were contacted contributed to the exposure and cases in that period and for the older infants such events related to the remote past. We may, therefore, infer that the gradient of inception rate over successive periods of infant life would have been even steeper if memory lapse had not occurred.

The reasons underlying the inordinately high inception rate in the neo-natal period and the sudden fall after that period may be clearly explained only if we analyse the total morbidity by causes in each of the periods. The following table shows the incidence in each age interval by various classes of diseases.

TABLE 22. DISTRIBUTION OF ILLNESSES BY CAUSES

time of on set in months after birth (1)	diarrhoea and dysentery (2)	infantile diarrhoea (3)	respiratory diseases (4)	measles and chicken pox (5)	diseases of the eye, ear, throat etc. (6)	dieases of the skin (7)	other infectious diseases (8)	malnutrition (9)	respiratory symptoms (10)	other symptoms (11)	total (12)
0— 1	5	12	4	3	8	4	1	10	27	8	82
1— 3	11	—	9	3	2	6	1	4	31	5	72
3— 6	18	—	12	6	5	5	1	1	21	10	79
6—12	24	—	14	6	4	5	4	—	17	10	84
total	58	12	39	18	19	20	7	15	96	33	317

It may be observed that 12 cases of infantile diarrhoea had been reported in this survey which have been wholly allocated to the neo-natal period. Out of 15 cases of severe mal-nutrition and rickets 10 cases have been reported to have occurred in the neo-natal period. It was noticed that of these only 2 had a birthweight lower than 5 lbs. It was observed that where lactation had failed or was very inadequate, mothers had a tendency to report rickets among their children. Out of 129 cases for which mere symptoms were reported 35 cases had occurred in the first month of life, and majority of these were respiratory symptoms like cold, fever and cough. Gastro-enteritis and respiratory symptoms together account for a major portion of the inception rate in the neo-natal period. Both these causes arise from the insanitary conditions and overcrowding prevailing among the poorer classes of the population. The lack of means to provide proper infant diet when lactation has failed leads to severe mal-nutrition. It may, therefore, be inferred that the origin of the causes of the excessive morbidity observed in the neo-natal period are chiefly social and are mostly preventable by a well-directed movement for promotion of environmental hygiene and health education.

If the morbidity for the entire period is considered, respiratory symptoms like cold, cough and fever emerge as the largest group which accounts for 96 cases or 30% of the total incidence. The 39 cases of respiratory diseases include 19 cases of pneumonia, 10 cases of bronchitis, 8 cases of whooping cough and 1 case each of diptheria and TB. If the class of respiratory symptoms and the class of respiratory diseases shown in the previous table are amalgamated to form a single class, then it would account for as many as 135 cases or 43% of the total incidence.

In the investigation conducted by Grundy and Lewis-Fanning (*loc. cit.*) they have observed that the respiratory diseases accounted for 47.8% of the total incidence (if whooping cough cases are added to these the proportion rises to 52.8%). In our investigation diarrhoea and dysentery come to be the second major group of causes of illnesses which accounted for 58 cases or 18.3% of the total incidence. In Great Britain the total inception rate was 89 cases per 100 infant years or 7.42 cases per 100 months whereas in this investigation we have observed an inception rate of 12.35 cases per 100 months. In the following table the distribution of illnesses by major groups of causes obtained in our investigation is compared with that obtained by Grundy and Lewis-Fanning for Great Britain.

TABLE 23. PERCENTAGE DISTRIBUTION OF ILLNESSES BY CAUSES
(Present survey and Great Britain)

cause	percentage to total incidence	
	(present survey)	Great Britain (1952-53) (Grundy and Lewis-Fanning)
(1)	(2)	(3)
1. respiratory diseases including respiratory symptoms	42.6	52.8
2. gastro-enteritis	3.8	9.0
3. measles and chickenpox	5.7	9.0
4. diseases of the eye, ear, throat etc.	6.0	7.9
5. diseases of skin	6.3	4.5
6. diarhoea and dysentery	18.3	1.1
7. other infections	2.2	
8. accidents and injuries	—	1.1
9. all other diseases	15.1	14.6
all causes	100.00	100.00

Only for 365 infants whose mothers were present at the time of the nurse investigator's visit the information on morbidity could be collected. Among them 40 deaths had occurred. Majority of these deaths were ascribable to prematurity and other causes of pre-natal origin. Some deaths for which causes were unknown and instantaneous deaths caused by accidents do not provide any specific morbid condition preceding death. The remaining deaths were considered for the estimation of case fatality rates. 3 deaths occurred among 58 cases of diarrhoea and dysentery, yielding a fatality rate of 5.2% and 4 deaths occurred among 12 cases of infantile diarrhoea, yielding a fatality rate of 33.3%. In all the remaining groups of causes together only 8 deaths had occurred and we do not think it worthwhile to present any case fatality rates for such diseases. The distribution of illnesses by causes clearly indicate that a sizeable proportion of the total volume of morbidity is attributable to such infections as could be prevented by proper environmental hygiene. The significance of this factor is further supported by the results of an analysis of inception rate by social class.

TABLE 24. INCEPTION RATE (NUMBER OF CASES PER 100 MONTHS OF EXPOSURE) BY SOCIAL CLASS

social class	exposure in months	number of cases	inception rate
(1)	(2)	(3)	(4)
high	643	59	9.18
middle	907	116	12.79
low	1020	142	13.92
all classes	2570	317	12.33

The inception rate for the lowest social class is 13.92 which is 1½ times as high as that observed for the high social class (9.18).

Development of the infant. The first year of life is a period of rapid growth and development. As regards physical growth the change in body weight is remarkable. By the fifth month the body is doubled and at the end of the first year it is trebled and thereafter the rate of gain in weight slows down steeply. The same may be said about body length and circumference of the head, although the relative rates of growth are not so striking. These rates of growth serve as useful indicators in deciding whether the baby has been making 'normal progress' or not. The age at which the fontanelle closes and the age at which milk teeth erupt are also used to assess the progress of growth of the infant. Usually the first tooth is cut at about the 7th month and the delay is ascribable to some disturbance in calcium metabolism.

Measurement of mental growth is more complex as it has to be gauged by certain activities of the child. The acquiring of individual skills, such as sitting, standing, walking etc. can be ascribed to the maturation of the appropriate part of the nervous system. The ages at sitting, standing etc. are therefore considered as milestones, marking definite stages in particular fields of mental development. There are considerable variations among children in the age at sitting, standing and other manifestations of gross motor development but most of these variations are considered normal. Environmental factors, specially lack of practice, are important causes for delayed motor development. There are indications of an association between prematurity and mental retardation.

It would have been most desirable in this enquiry to assess physical growth in terms of body weight, particularly in view of the fact that the birthweights were already recorded in the hospital. Unfortunately due to practical difficulties in weighing infants in their homes at the time of investigator's visit no information could be collected on this important aspect of physical growth. The only information of physical growth that could be readily collected was the one on dentation. Even in this case the data merely related to the age at first eruption of teeth and not to sequence in which different types of teeth erupted.

In the case of mental growth we had to restrict the scope of the enquiry to the age at sitting and standing because these are usually remembered by the mothers. The ages at walking, talking etc. which are learned by the infants at more advanced ages had to be excluded from this enquiry because the mothers were visited before the end of the first year.

Each mother whose infant was surviving on the date of survey was asked whether her baby has already learned to sit without support. If she said 'yes' she was further asked to report the age of the infant at sitting in months. Attempt to obtain returns of age at sitting in weeks was considered futile because the information had to be elicited retrospectively in a single interview. The same procedure was adopted for eliciting information on the age at the first eruption of teeth (age at dentation) and the age at which the child could stand without help from others.

Dentation. Of the 318 surviving infants for whom the information on development has been obtained, 119 or 37% of the infants were interviewed before the 6th month. Except for one child who was born with teeth none in this group were reported to have had the first tooth cut by the time of interview. Starting from the 6th month the proportion of infants reported to have had already the first tooth erupted steadily increased. It was, however, observed that about 14% of the infants contacted at the 12th month had shown no signs of dentation and these were obviously extreme cases of delayed dentation. The following table gives the number of infants reported to have had dentation before the date of interview.

TABLE 25. NUMBER OF INFANTS WHO HAD DENTATION BEFORE INTERVIEW

age in months at interview	number of infants interviewed	number of infants who had dentation already
< 4½	110	1
4½—5½	9	0
5½—6½	26	2
6½—7½	23	5
7½—8½	17	3
8½— 9½	17	5
9½—10½	12	9
10½—11½	24	22
11½—12½	80	69
total	318	116

The median age at dentation can be obtained in the same manner as the median lethal dose is estimated from the dose response curve in bio-assay. Here the dose metameter is represented by the age at interview and the response is measured by the proportion reported as having had the first tooth cut before the date of interview. The curve representing the above relationship has been obtained by freehand graph and shown in Fig. 1.

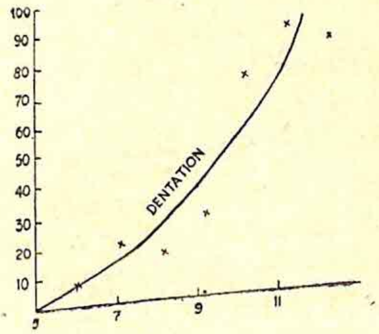

Fig. 1. Percentage of infants reported to have had dentation at various ages.

The median age at dentation obtained from this graph is 9.0 months. If the child has had dentation already the exact age in months at dentation was known. A very small minority of mothers could not report such ages. In what follows such cases of unknown ages at dentation were assumed to be distributed in the same manner as the known cases but of the same age at interview.

It should be borne in mind that in the estimation of the median age at dentation by the graphical method described above, we did not use the information, on when exactly the child had dentation. When the sample sizes are small, as for example in comparing two or more subgroups of infants, it may be worthwhile to avail of this additional information to obtain more accurate estimates.

One of the methods usually adopted for this purpose is the method of censored distribution of type I. (Hald, 1949 ; Grundy, 1952 and Gupta, 1952). Let n_{ij} be the number of infants contacted in the i-th month and n_i be the number reported to have not had dentation till interview and the number reported to have cut the first tooth exactly in the j-th month be $n_{ij}(j = 1, 2, \ldots, i)$

Thus we have
$$n_i = \sum_{j=1}^{i} n_{ij}+\bar{n}_i.$$

If we discard the information on all infants contacted before any specified month, say, the t-th and pool together the data of all infants contacted at the t-th month or after we obtain a censored distribution given by

$$\sum_{i=t}^{12} n_i = S_1+S_2+\ldots+S_j+\ldots+S_t+\left[\sum_{i=t+1}^{12}\sum_{j=t+1}^{i} n_{ij}+\sum_{i=1}^{12}\bar{n}_i\right] \qquad \ldots \quad (1)$$

where
$$S_j = \sum_{i=t}^{12} n_{ij}.$$

The l.h.s. of equation (1) gives the total number of infants contacted at the t-th month or later and among these $\left[\sum_{i=t+1}^{12}\sum_{j=t+1}^{i} n_{ij}+\sum_{i=t}^{12}\bar{n}_i\right]$ did not have the first tooth cut until the t-th month and

$$\sum_{j=1}^{t} S_j = \sum_{j=1}^{t}\sum_{i=t}^{12} n_{ij}$$

had it before the t-th month. Each term S_j in the r.h.s. of (1) represents the number of infants who had dentation exactly in the j-th month. This is a censored distribution of the age at dentation truncated at the t-th month. As stated earlier the infants contacted before the t-th month do not enter this picture at all, no matter whether they had the first tooth erupted or not. This implies the loss of the entire information from this sector and further removal of the point of truncation from birth means greater loss of information. On the other hand, if 't' is shifted towards the left, there will be greater lumping of the frequencies to the right of 't' and consequently we know less about the nature of the distribution. For the age at dentation the truncation point has been taken in this analysis as 10 months, which seemed a suitable compromise for the two opposing considerations. The mean and standard deviation of the original population from which the above is a censored sample has been obtained by the method of maximum likelihood. The estimating function for the sample mean (μ^*) and standard deviation (σ^*) are given in simple forms convenient for computation by Gupta (*loc. cit.*).

These are
$$\mu^* = \bar{x}+(\sigma^{*2}-S^2)/(x_k-\bar{x}) \qquad \ldots \quad (2)$$
and
$$\sigma^* = (x_k-\bar{x})/Z \qquad \ldots \quad (3)$$

where x_k $\bar{x}$ and S are respectively the largest observation, mean and standard deviation of the part of the sample lying to the left of the point of truncation and Z is given by the two equations (4) and (5) below.

$$Z = \eta + \frac{\left(\frac{n}{k}-1\right)}{e^{\eta^2/2}} \left[\int_{\eta}^{\infty} e^{-t^2/2}\, dt \right]^{-1} \qquad \ldots \quad (4)$$

and

$$\frac{S^2}{s^2+(x_k-\bar{x})^2} = \frac{1+\eta z - z^2}{1+\eta z} \qquad \ldots \quad (5)$$

where

$$\eta = \frac{x_k-\mu^*}{\sigma^*}$$

where k/n is the proportion of the part to the left of the point of truncation in the sample of size 'n'. The standard error of the mean etc. is obtained readily from the inverse of the information matrix.

$$\frac{-\sigma^2}{n} \begin{pmatrix} \frac{\partial^2 \log L}{\partial \mu^2} & \frac{\partial^2 \log L}{\partial \mu\, \partial \sigma} \\ \frac{\partial^2 \log L}{\partial \sigma\, \partial \mu} & \frac{\partial^2 \log L}{\partial \sigma^2} \end{pmatrix} \qquad \ldots \quad (6)$$

L^* being the likelihood function of the censored sample. The above procedure is applicable only in the case when the variable considered is normally distributed. As the distribution of the age at dentation of children included in this sample was somwehat skew a logarithmic transformation of the age scale was necessary to make it conform to a normal distribution. The estimates obtained in the new scale were retransformed to original age scale and presented in the tables below.

Factors affecting physical development. The physical development of the child is largely conditioned by a number of factors such as the pre-natal conditions and the nutritional intake of the child. To assess the effect of pre-natal condition on physical growth of the children, they have been classified into 3 groups according to birth weight and for each group the average age at dentation has been estimated by the method described above. The estimated averages with their standard errors are presented in Table 26.

TABLE 26. AVERAGE AGE AT DENTATION BY BIRTHWEIGHT CLASS

birthweight class (in lbs.) (1)	number of infants contacted at 10th month or later (2)	age at dentation (3)	standard error of the mean (4)
less than 6	37	9.288	1.035
6–7	42	7.883	1.030
7 and over	37	8.370	1.037
total	116		

$$L^* = \frac{n!}{(k-1)!\,(n-k)!}\, e^{-\frac{1}{2\sigma^2} \sum_{i=1}^{k} (x_i-\mu)^2} \left[(\sigma\sqrt{2\pi})^{-1} \int_{x_k}^{\infty} e^{-\frac{1}{2\sigma^2}(x-\mu)^2}\, dx \right]^{n-k}$$

From the above table it appears that babies weighing 6-7 lbs at birth had a lower age at dentation than those weighing less than 6 lbs. On the other hand, as we proceed to the next higher birthweight class, 7 lbs and over, we notice a slight increase in the age at dentation, although the observed increase is statistically not significant.

To study the effect of infant diet on growth information on the quantities of of items included in the feeding during successive months after birth was obtained. Almost the entire sample of infants surveyed belonged to the poorer classes and their nutritional lavels were indeed low. However, a classification based on milk intake, gave rise to two groups, one moderately adequate and the other inadequate in nutritional intake. Breast feeding without substitute was considered as adequate nutritional intake for the period concerned. For these two groups, the average age at dentation was estimated by the same procedure as before and shown together with their standard errors in Table 27.

TABLE 27. AVERAGE AGE AT DENTATION BY NUTRITIONAL LEVELS

nutritional level	number of infants contacted at 10th month or after	age at dentation in months	standard error of the mean
(1)	(2)	(3)	(4)
moderately adequate	60	8.610	1.028
grossly inadequate	56	9.669	1.027
total	116		

From the figures given in the above table it appears that dentation is delayed in the case of infants belonging to the grossly inadequate nutritional group. Failure of lactation and want of suitable substitute no doubt retard growth. Calcium metabolism is also affected. But these alone are not the factors concerned because a classification according to nutritional level also leads to one based on the social class. It was observed earlier that the proportion of infants with low birth weights was higher among the lower social class. Further it was in this class that a higher incidence of morbidity was recorded. As both these factors retard growth the higher age at dentation observed among the infants belonging to the grossly inadequate diet group cannot be entirely ascribed to nutritional deficiency.

Mental development. Development is a continuous process from conception to maturity and birth is merely an event in the course of development, though it signals the beginning of environmental influences. A prematurely born infant is developmentally behind a baby born at full term, although the former passes through the same sequence of mental developments.

Case histories of infants affected by various diseases of the nervous system and how such diseases had retarded mental developments in different fields have been reviewed by Illingworth (1960). He has stated that such variations are not confined to diseased cases only, because even those infants who gave no evidence of any impairment behaved so differently in their mental development that it is impossible to draw a dividing line between the normal and the abnormal. Accordingly he has given a series of averages for the ages at attaining different stages of mental development and has cautioned that deviations, however large they may be, do not necessarily indicate abnormality. It is pertinent here to quote some of these figures and observe how they compare with the results of this survey.

Sitting. Age 28 weeks; sits on floor with hands forward for support; age 32 weeks : sits momentarily on the floor without support; age 36 weeks : sits steadily on floor for 10 minutes, leans forward (but not sideways) and recovers balance.

Standing. Age 36 weeks : stands holding on to furniture—pulls self to stand; age 44 weeks : standing, lifts foot.

The acquiring of any of these skills does not occur at a point of time but it is a gradual process spread over a period of month or so.

In this enquiry the age at sitting has been reckoned as the age at which the child could sit steadily without support and the age at standing as the age at which the child could stand easily and balance for a while without help from others.

The median age at sitting and standing has been obtained by the same graphical method as the one adopted in the study on age at dentation. The distribution of infants according to their age at contact is shown in the first row of Table 28 and the number of infants in each age group who had already learned to sit is given in the second row. In the third row of the same table is given the number in each group who have already learned to stand.

TABLE 28. NUMBER OF INFANTS ALREADY LEARNED TO SIT AND TO STAND IN DIFFERENT AGE GROUPS

	age in months at the time of interview									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	below 4½	4½-5½	5½-6½	6½-7½	7½-8½	8½-9½	9½-10½	10½-11½	11½-12½	total
number of infants	110	9	26	23	17	17	12	24	80	318
number of infants already learned to sit	—	2	6	16	11	12	10	21	75	153
number of infants already learned to stand	—	—	—	1	2	4	5	11	55	78

Graphs drawn by free-hand to depict the variation of the proportion of infants who already learned to sit by the time they attained a given age and a similar one for those who learned to stand are shown in Fig. 2.

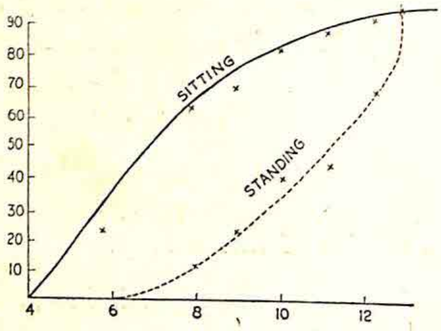

Fig. 2. Percentage of infants already learned to sit and stand.

By the 8th month of age nearly two-third of the infants already learned to sit and by the 10th month 5/6th of the infants have passed that stage. A very small minority could not sit even at the end of the year and these are cases of delayed motor development. Slightly over two-third of the children learned to stand by the 12th month of life. The median age at sitting and standing obtained from the above graphs are 7.00 and 10.93 months respectively. The age at standing appears to be slightly more advanced than that obtained for normal children by Illingworth (1960) and this is not entirely due to the fact that the survey sample included an appreciable number of children in the low birthweight class as will be seen from Table 29.

Just as in the case of the age at dentation, for the ages at sitting and standing as well, we can obtain censored distributions with suitable points of truncation. After examining the distribution of the ages at sitting and standing, 8th month and 11th month were selected as points of truncation for obtaining the censored distribution of the ages at sitting and standing respectively. In what follows the average ages at sitting and standing have been estimated by the same method as the one adopted in the study on dentation. A logarithmic transformation of the age scale was carried out for the same reason.

Factors affecting mental development. To assess the influence of birthweight the infants were grouped into birthweight classes as before and the average ages at sitting and standing with their respective standard errors were estimated and shown in Table 29.

TABLE 29. AVERAGE AGES AT SITTING AND STANDING BY BIRTHWEIGHT CLASS

birthweight class	number of infants contacted 8th month or after	age at sitting in month		number of infants contacted at 11th month or after	age at standing in months	
		mean	standard error of mean		mean	standard error of mean
(1)	(2)	(3)	(4)	(5)	(6)	(7)
less than 6 lbs.	42	7.752	1.023	35	14.381	1.038
6–7 lbs.	59	7.444	1.025	38	12.712	1.025
7 lbs and over	49	7.236	1.024	31	12.644	1.024
total	150			104		

From the above table it appears that as the birthweight increases both the age at sitting and the age at standing are steadily lowered which is suggestive of the influence of pre-natal factors on mental development during the first year of life.

A classification according to infant diet generally leads also to a classification based on social class for reasons stated earlier. Further, a mother who nourishes her baby well may be expected to take better care of her child in other respects too. A dietary classification may, therefore, involve many environmental factors and some of these may affect the maturation process. In the following table are presented the estimates of the average ages at sitting and standing with their respective standard errors for two infant diet groups.

TABLE 30. AVERAGE AGE AT SITTING AND STANDING BY NUTRITIONAL LEVEL

nutritional level	number of infants contacted at 8th month or after	age at sitting in months		number of infants contacted at 11th month or after	age at standing in months	
		mean	standard error of mean		mean	standard error of mean
(1)	(1)	(2)	(3)	(1)	(2)	(3)
moderately adequate	83	7.236	1.019	56	12.690	1.035
grossly inadequate	67	8.523	1.030	48	12.757	1.023
total	150			104		

We observe from the above table that the age at sitting has been appreciably advanced in the case of the grossly inadequate diet group but the same thing cannot be said about the age at standing.

4. CONCLUSIONS

(1) The infant mortality rate for the selected sample of 521 infants was 147/1000 live births of which 100/1000 and 47/1000 were the neo-natal and post-neonatal components respectively.

The leading cause of death during the neo-natal period was prematurity unqualified and prematurity associated with other causes. A maturity standard in terms of birthweight was worked out taking into account the chance of survival and a level of 5 pounds was found to be reasonably satisfactory. Incidence of prematurity was considerably higher in the general hospital population because it included a number of unbooked cases arriving from distant suburbs. Further, it was observed that the proportion of premature infants was higher in the lower social classes.

Infant mortality tended to decline with parity. Also it varied inversely with standards of housing, maternal diet, father's income and education. Peculiarly enough, infants born to women who made adequate number of antenatal visits experienced higher mortality. Closer scrutiny, however, revealed that antenatal visits were mostly undertaken for treatment of maternal complications and not as a routine preventive measure.

(2) The inception rate for all causes of morbidity was 12.3 cases/100 months of exposure. Respiratory diseases was the leading group of causes of morbidity followed by diarrhoea and dysentery. Inception rate varied inversely with social class.

(3) (a) Physical growth was measured in terms of age recorded in this case was 9.00 months. Marked delay in dentation was observed both among the infants with low birthweight and among those who were given poor nourishment.

(b) Mental development was measured in terms of age at sitting and age at standing. The median age at sitting and standing were 7.00 months and 10,93 months respectively. Low birthweight was observed to retard motor development as indicated by the age at sitting and standing, the latter significantly.

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Appendix

INDIAN STATISTICAL INSTITUTE
FOLLOW-UP STUDY OF IN-PATIENTS OF MATERNITY WARDS
PART I : HOUSEHOLD SCHEDULE

name and address of the patient..

name of the husband of the patient...

(1) is the patient living in this household ? yes no

(2) if no in (1), what is her present address ?

(3) if no in (1), did she stay in this household after leaving the hospital ? yes no

if yes in (3)—(a) how long ?

(b) what was the condition of the mother and infant during her stay here and after ?

(survival of the mother and infant *must be obtained* and details about complications and medical care may *be obtained if the response is reliable*)

(4) if yes in (1), the following information must be collected :

name of the member	relation to the head of the household	sex	age	marital status	educational status	if earner	
						occupation	income
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)

migratory status of the head of the household— *migrant* *non-migrant*

if migrant, enter district and state of origin.

actual duration of stay in years

rural	town	Calcutta city

housing conditions

house owned—rented	rental value	number of living rooms— store— kitchen—	separate 1 common 2 nil 3	bath	privy	water supply

appointment for medical investigation on..............at...................

signature of the Investigator
date :

PART II : HOSPITAL RECORDS

(to be filled in after field enquiry)

age	period of pregnancy	order of the gravidae	complications as reported in the hospital	duration of labour in hours	condition of mother	condition of infant	birth and weights of the infant
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)

INDIAN STATISTICAL INSTITUTE
FOLLOW-UP STUDY OF IN-PATIENTS OF MATERNITY WARDS
PART III : PATIENTS' SCHEDULE

signature of the investigator & date

Block (1)

1. patient's name and address
2. her relation to the head of the household
3. does her husband reside in this household ? yes no
4. husband's name— age
   occupation education income
5. date of discharge from hospital cabin paying non-paying
   nature of current termination live birth still birth abortion
   associated complication

Block (2)

1. period of confinement to bed after leaving the hospital months days
   did you resume normal work after confinement yes no
   if 'no' what were the restrictions—
   how long the restrictions continued ? months days
2. after the current termination, did you menstruate ? yes no
   if 'yes' date of first onset—
   pain associated—
   interval— in days—
   since then did you miss any period ? yes no
   if 'yes' remarks about new conception—
3. lactation— success— partial failure— complete failure—
   if not, complete failure, are you lactating now ? yes no
   if no, when it did cease completely—
4. did you have any complications in the (in months after child birth) last pregnancy ?
   if 'yes' state its nature.

ante-natal visits* [ ]	stage of pregnancy in months when visits were made	treatment availed
first in hospital/physician		
second in hospital/physician		
third in hospital/physician		

* if no ante-natal visits were made, enter 'nil' in the space within brackets.

BLOCK 3 : POST-NATAL HISTORY

group	symptom	remarks	onset—days or months after child birth	continuance, if not duration	visits		treat-ment
					hosp.	physi.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A. uterine sub-involution and retroversion	1. back-ache						
	2. white vaginal discharge						
	3. prolonged and frequent vaginal bleeding						
	4. red lochia						
B. genital tears	1. ununited or unrepaired perenaeal tear						
	2. cervical tears						
	3. eversion of lips						
	4. incontinence faeces						
	5. complete perenial tears						
	6. recto-vaginal fistula.						
C. genital prolapse	1. bearing down sensation and something coming out per vagina with/without straining						
	2. abdominal pain-dragging in nature						
D. urinary symptoms	1. incontenence of urine true, stress, urge						
	2. frequency						
	3. buring sensation during urination						
	4. temperature						
	5. pain in the loins						
E. breast complications	1. painful enforgement of breast						
	2. abscess						
	3. mastitis (severe, painful engorgement with rise in temperature)						
	4. cracked, fissured or ulcerated nipples						
F. pelvic inflamation and puerperal sepsis	1. rise of temperature						
	2. pain in abdomen						
	3. red lochia						
	4. offensive or scanty lochia						
	5. irregular haemorhage						
	6. swelling in lower abdomen						
	7. painful swelling of 1 of the legs						
	8. chronic cervities with/without erosions						
G. other post-natal complications	1. obesity						
	2. anaemia						
	3. headache						
	4. insomnia						
	5. scanty urine						
	6. swelling of both legs						
	7. constipation, piles and gastro intestinal symptoms						
	8. puerperal insanity						
	9. obstetrical paralysis of the lower limbs						

(a) were any routine post-natal checks carried out by physicians (even without complications)
if 'yes' time of examination in weeks after childbirth
1st examination ( ) 2nd examination ( ) 3rd examination ( )

yes no
yes no

(b) were any advices on post-natal exercises given—
if 'yes' state the method of exercises advised and whether they were practised

yes no

(c) was any advice on family planning given—
if 'yes' state details

(d) what is your normal diet, i.e., before pregnancy what was your usual diet ?
(state quantities of meat, fish, eggs and milk taken per day)
fruits and vegetables—
did you take any additional quantities of the above items
(1) during pregnancy state (including tonics)
(2) after child-birth—

BLOCK 4

Infant

1. sex 2. birth-weight 3. gestation period 4. surviving or dead

5. if surviving present age 6. if dead, age at death in month and days

7. cause of death (describing the train of events leading to death)

8. if surviving, give the health history of the infant below :

age	name of the disease with symptoms	attendance to physician, hospital etc.	treatment availed	result		
				cured	partially cured	not cured
0–1 week						
1 week–1 month						
1–3 month						
3–6 month						
6 month and above						

9. *Development*

(a) activity (age in months at which baby was sitting, standing etc., may be ascertained)

(b) sucking and breathing reflex—

(c) bowels

(d) dentation

(e) general appearance

10. *Feeding*

item	quantity per day	period in months
1. breast milk		
2. cow's milk		
3. other types of milk (state brand)		
4. cereals		
5. fruits		
6. fish		
7. meat		
8. eggs		
9. tonics		

BLOCK : PREVIOUS PREGNANCY HISTORY

age at marriage												
order of parity	1	2	3	4	5	6	7	8	9	10	11	12
age of the mother												
result of pregnancy												
complications in labour												
post-natal complications												
whether hospital delivery												

Chronic diseases of the mother (if any) : 1. T.B. ; 2. diabetes ; 3. heart disease ; 4. essential hypertension ; 5. nephritis 6. rheumatism ; 7. gastric troubles ; 8. others (state the exact cause) ;

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WORKING FORCE SIZE AND STRUCTURE IN INDIA, 1951 : A REGIONAL ANALYSIS OF CENSUS AND SAMPLE SURVEY DATA

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Indian Statistical Institute

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WORKING FORCE SIZE AND STRUCTURE IN INDIA, 1951 : A REGIONAL ANALYSIS OF CENSUS AND SAMPLE SURVEY DATA

1. Introduction

This paper reports the findings of a region-by-region analysis of the 1951 Census economic returns, with particular respect to size of working force and balance between agricultural and non-agricultural occupations. Wherever possible, Census figures for States or parts of States have been critically compared with the results of three All-India sample surveys conducted between 1950 and 1955 : the Agricultural Labour Enquiry, the National Sample Survey, and the Rural Credit Survey. Our primary aim in examining the Census of 1951 materials has been to assess their value as a statistical base against which the 1961 Census returns may be appraised and interpreted. The study was carried on as one part of the research programme of the Census of 1961 Project of the Indian Statistical Institute.[1]

2. Summary results

Summarizing our conclusions, we may say that internal as well as external evidence points to a high degree of unreliability in the Census of 1951 data on working force participation. The proportion of the population classed by the Census as earners varied sharply from State to State without relation to differences in age structure. Rather, the percentage of males and females recorded as self-supporting, partly dependent, or totally dependent tended to follow particular patterns according to the separate jurisdictions under which the census was conducted. Several of these census-taking jurisdictions, however, cut across tracts well known to be fairly uniform in geographic, social and economic characteristics, which would normally be reflected in fairly uniform working force proportions. It would appear that exogenous factors, chiefly of an administrative nature, seriously influenced the Census returns.

Working force percentages for States and parts of States obtained by two different sample surveys show practically no relation with the Census figures for the same areas. Both surveys found significantly larger proportions of workers in the *rural* population than did the Census. Taken together, the survey results suggest that the Census seriously under-enumerated the *rural* working force in the country as a whole, and particularly in the South. Since approximately five-sixths of the 1951 population was rural, it would seem that the Census figures for earners and part-earners provide a dependable guide neither to the actual numbers of workers in different regions of India, nor to the variation among regions in the proportion of the population engaged in economically productive activities.

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[1] The Project was sponsored by the Indian Statistical Institute through its Bombay Branch as a contribution to the preparations for the ninth decennial Census of India. The scope of the Project may be indicated by mentioning the titles of some of the earlier reports : "Preliminary Memorandum — Economic Concepts in the Census of India, 1881–1951," cyclostyled, 1958; "Comparability of Census Economic Data, 1881–1951", cyclostyled, 1958; "Census Economic Questions and Tables : Some Alternative Tryout Proposals", cyclostyled, 1958; "Economic Recommendations for the Census of 1961," *Economic Weekly* (Bombay), Vol. XI, pp. 1230-1242, September 5, 1959.

Daniel Thorner served as Director of the Project, Alice Thorner as Joint Director, and Neena C. Shah as Computer. M. A. Telang, Honorary Secretary of the Bombay Branch, provided advice and guidance at all stages of the work.

By contrast, we have found the Census distribution of the working force of the several regions into broad occupational groups reasonably in accord not only with generally accepted accounts of local characteristics but also with relevant sample survey data. Putting together the evidence from the Census and the sample enquiries we are able to identify with some confidence rural tracts where the population consists primarily of peasant cultivators and their families, tracts with significant numbers of hired agricultural labourers, and tracts in which a sizeable fraction of the working force is engaged in non-agriculture.

High percentages of cultivators were typical of Himalayan border districts from Himachal Pradesh and Kangra on the west to Assam and Tripura on the east; of interior hilly regions in Madhya Pradesh and Bihar where substantial tribal populations dwell; of the Konkan and Deccan regions in Maharashtra; and of parts of the Gangetic and Trans-Gangetic Plains in Rajasthan, Punjab, and Uttar Pradesh. Agricultural labourers played an important role in the South (Andhra, Kerala and Madras); also in the easterly districts of Maharashtra (Berar and Marathwada), in the central region of Madhya Pradesh, and in North Bihar. Non-agricultural pursuits claimed significant proportions of the rural working force in the areas of Uttar Pradesh and Punjab adjacent to Delhi, and along almost the entire coastal rim from Kutch and Saurashtra down to the southernmost tip and up again to West Bengal.

3. COMPARABILITY OF SURVEYS WITH CENSUS

Purposes of surveys. The Agricultural Labour Enquiry (ALE)[2] was undertaken by the Ministry of Labour as a preliminary to drawing up measures to ameliorate the conditions of agricultural labour. The second stage, the results of which we have employed, was entitled the General Family Survey; it covered 103,548 families in 812 villages. The National Sample Survey (NSS)[3] has been conducted on a continuing basis since 1950 by the Government of India with the assistance of the Indian Statistical Institute. It is a multipurpose survey, gathering data on a wide variety of economic, social, and agricultural topics. The Ninth Round covered 16,000 households in 1624 villages and 32,000 households in 2108 urban blocks. The Rural Credit Survey (RCS)[4] was sponsored by the Reserve Bank of India with the aim of providing information required for the formulation of long-term agricultural credit policy. The RCS collected data from 120,000 families in 600 villages.

Reference dates. The Census was taken in March 1951; the General Family Survey of the Agricultural Labour Enquiry was conducted early in 1950; and the field work of the Rural Credit Survey extended from October 1951 through early 1952. It is not unreasonable to take the data from the latter two sources as referring to roughly the same point in time as the Census. The Ninth Round of the National Sample Survey, however, covered the months May–November, 1955. We have nonetheless used the Ninth Round materials since this was the first NSS round large enough to yield estimates for separate States. We have been emboldened to ignore the four-year gap by the fact that the Ninth Round All-India data relating to the subjects included in our comparisons are highly consistent with the relevant All-India figures from the First Round (October 1950—March 1951) and the Fourth Round (April—September, 1952). It is, of course, possible that there may have been State-wise variations during this period, but we have not attempted to pursue this possibility.

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[2] *Rural Manpower and Occupational Structure.* Ministry of Labour, Government of India, Delhi, 1954.

[3] National Sample Survey : Number 16 : *Employment and Unemployment* : Ninth Round, Preliminary, May–November, 1955 Cabinet Secretariat, Government of India, Delhi, 1959.

[4] All-India Rural Credit Survey : Survey Report Vol. I, Part I, *Rural Families*, Reserve Bank of India, Bombay, 1956.

Geographical units. While we have in effect assumed away any important influence of the time factor, we have taken some pains to bring the data into geographical equivalence. Each of the Surveys utilized a different break-down of the All-India figures by States, groups of States, and part of States. No one of the other sources followed exactly the procedure of the Census. Keeping in mind the needs of 1961, we have attempted, wherever possible, to draw up our tabulations in terms of the current States. This has involved recombination of Census "natural divisions" (groups of districts within the 1951 State boundaries) and ALE zones (parts of States).

Appendix 1 shows the districts included in each Census natural division, and the ALE zone or zones taken as equivalent to each division. For ease of reference we have given each division a descriptive, popular or historical name, e.g., Coastal Andhra, Telengana, Chhota Nagpur. The three-digit Census code numbers (e.g, 1.21 for Assam Valley, and 2.12 for North Bihar) denote the position of the division with regard to five major geographical regions (single-digit codes 1 to 5) and fifteen sub-regions (two-digit codes). The ALE zones are identified by roman numerals following the name of the State in which the area was included in 1951. From the names of the ALE zones, for example, we can understand at a glance that Andhra State has been constituted from parts of the former territories of Madras and Hyderabad.

Where we have been unable to obtain data referring to divisions we have presented comparisons in terms of States. In some cases this has been possible to do for the 17 major States which existed in 1951, in others for only the 9 "Part A" States plus Andhra, which was separated from Madras in 1953. Readers are cautioned that of these ten States, one (Bombay) has been broken up completely, another (Madhya Pradesh) is today constituted quite differently, three (Andhra, Madras and Punjab) have undergone changes of somewhat lesser magnitude, and another two (West Bengal and Bihar) have had minor border adjustments. Only Assam, Orissa and Uttar Pradesh have remained virtually unaffected. The comparison between Census and RCS materials has been made for individual districts because of the nature of the RCS sample.

As is only to be expected, each of the three Surveys has a different emphasis than the Census. Each employs its own set of definitions. We will take account of these conceptual discrepancies in the discussion of the particular comparisons for which they are relevant.

4. WORKING FORCE SIZE : DISCREPANCIES IN CENSUS DATA

Census economic classification. The three categories into which the Census of 1951 classified the entire population were "self-supporting persons" (individuals in receipt of income sufficient at least for their own maintenance), "earning dependents" (individuals in receipt of income insufficient for their own maintenance), and "non-earning dependents." In the Census literature, these terms are referred to as indicating "household economic status." This is, of course, not exactly the same as a classification into workers and non-workers, or economically active and not economically active, since the focus is on receipt of income rather than work. However, the number of persons who receive income without working is very small. Only about 1 percent of the total population in 1951 were recorded as rent-receivers, beggars, pensioners, etc. The question of persons (such as family members helping in cultivation) who work but receive no overt income in wages or profits presents more difficulties. The Census instructions indicated that such individuals were to be classed as either self-supporting persons or earning dependents according to the share of the family income attributable to them. As we shall see, this instruction was interpreted in many different fashions.

We may begin our examination of the Census data by inspecting the percentage of all earners—self-supporting persons (SSP's) plus earning dependents (ED's)—identified in each of the major States. Table 1 shows these percentages for persons

TABLE 1. PERCENTAGES OF SELF-SUPPORTING PERSONS PLUS EARNING DEPENDENTS IN 17 STATES COMPARED WITH PERCENTAGES OF PERSONS IN WORKING AGE GROUP (15–64)

major States*	all persons		males only	
	persons in age group 15–64 per 100 persons	SSP's+ED's per 100 persons	persons in age group 15–64 per 100 males	SSP's+ED'S per 100 males
1. West Bengal	62	35	64	55
2. Madras	61	31	61	47
3. Vindhya Pradesh	60	46	59	59
4. Madhya Bharat	59	41	60	57
5. Orissa	59	38	59	57
6. Madhya Pradesh	58	56	58	64
7. Hyderabad	58	46	58	60
8. Bombay	58	43	59	55
9. Uttar Pradesh	58	42	59	59
10. Travancore-Cochin	58	36	57	50
11. Mysore	58	29	59	48
12. Rajasthan	57	50	57	61
13. Saurashtra	56	42	56	53
14. Bihar	56	36	56	50
15. Assam	55	43	56	54
16. PEPSU	55	39	55	60
17. Punjab]	54	39	55	56
high	62	56	64	64
low	54	29	55	47
range	8	27	9	17

*As of 1951.

of both sexes and also for males only. Percentages for females as well are presented in Appendix 2, Table A.1. Since Census of 1951 economic data were not cross-tabulated by age, we could not calculate age-specific working force proportions. Instead we have compared the percentages of workers with the percentages of persons in the age group 15-64.

Statewise variation in working force proportions. We note with some surprise that whereas 56 of every 100 persons in Madhya Pradesh were returned as fully or partly self-supporting only 29 of every 100 were so returned in Mysore. As against 47 earners per 100 males in Madras, the ratio in neighbouring Hyderabad was 60 per 100. Difference from State to State in the proportions of persons in the working ages (15-64) provide no basis for such wide variations in working force size. On the contrary, Madras had a somewhat more favourable age structure (61 out of every 100 persons in the 15-64 group) than Hyderabad, while Mysore and Madhya Pradesh were practically identical in this respect. Nor do the discrepancies tally with other available information about conditions in the various States.

We may continue by studying the relative numbers of persons recorded respectively as SSP's (self-supporting persons), ED's (earning dependents) and NED's (non-earning dependents) in the 52 natural divisions. Table A. 2 in Appendix 2 presents the percentages separately for males and females. Our discussions focus primarily on the data for males, since they comprise the bulk of the working force and economic returns relating to males are well known to be more reliable than those for females.

Difference among divisions. Table 2 shows the extent of regional variation in the percentages of males assigned to each of the three categories. Let us for the moment leave out of consideration the two highly atypical divisions of Greater Bombay and Calcutta Industrial Area. We find that the proportion of males returned as self-supporting ranged from 55.9 in the hill tract of Himachal Pradesh on the northwest frontier to 39.5 in Manipur, a hill tract on the northeast frontier. With regard to earning dependents the highest percentage was that for the Himalayan principality of Sikkim, 19.4, while the lowest was 2.6 for the neighbouring Darjeeling-Duars area. The division with the largest percentage of non-earning dependents was the coastal Malabar-South Kanara area of the old Madras State, with a figure of 55.5; the smallest percentage of non-earners was 32.8 in Himachal Pradesh. In parts of Madras, in Mysore and in South Bihar, less than one out of every two males was recorded as an earner (either SSP or ED). By contrast, in Himachal Pradesh and the Chhattisgarh area of eastern Madhya Pradesh, approximately two out of every three males were classed as earners. Table A. 2 in Appendix 2 will show that the disparities in the percentages for females are still greater.

Yet we know that the Indian economy, while not of an uniform texture, is nonetheless characterized by a certain basic sameness. The agricultural villages which predominate in every part of the country offer, in point of fact, little scope for variation in the pattern of working and not working (or earning and not earning), especially

TABLE 2. DIVISIONS ARRANGED IN RANK ORDER OF PERCENTAGES OF SELF-SUPPORTING PERSONS, EARNING DEPENDENTS AND NON-EARNING DEPENDENTS TO ALL MALES

rank number	self-supporting persons		earning dependents		non-earning dependents	
	division	percentage	division	percentage	division	percentage
1.	Greater-Bombay	65.3	Sikkim	19.4	Malabar	55.5
2.	Calcutta Area	62.7	Marathwada	16.9	Tamilnad	53.6
3.	Himachal	55.9	Chhattisgarh	14.7	Rayalaseema	53.1
4.	West U.P.	55.7	Kangra	14.3	South Bihar	53.1
5.	Delhi	53.6	Telengana	14.0	Mysore	52.3
6.	Kotah-Bundi	53.2	Manipur	13.7	Travancore-Cochin	50.3
7.	Ajmer	52.8	Berar-Nagpur	12.1	North Bihar	50.1
8.	Patiala	52.7	Jabalpur-Sagar	11.5	Coastal Andhra	49.2
9.	Jaipur-Alwar	52.5	Himachal	11.4	W. Bengal*	48.0
10.	Jodhpur-Bikaner	52.5	Assam Valley	11.4	Konkan	47.4
11.	Coorg	52.0	Saurashtra	11.4	Chhota Nagpur	47.1
12.	Bhopal	51.6	Mewar	10.7	Gujarat	46.9
13.	Darjeeling-Duars	51.6	Punjab Plain	10.6	Manipur	46.8
14.	Oudh	51.5	North Karnatak	10.4	Bombay Deccan	46.7
15.	South U.P.	51.3	Orissa Inland	9.8	Saurashtra	46.5
16.	Kumaon-Garhwal	50.8	Tripura	9.8	Assam Valley	46.0
17.	Gwalior	50.7	Bombay Deccan	9.7	Darjeeling-Duars	45.8
18.	Chhattisgarh	50.7	Assam Hills	9.6	Assam Hills	45.8
19.	Jabalpur-Sagar	50.6	Bundelkhand	9.5	Coorg	44.8
20.	East U.P.	50.0	Jaipur-Alwar	9.5	Kutch	44.7
21.	Malwa	49.8	Kotah-Bundi	9.2	North Karnatak	44.6
22.	Berar-Nagpur	49.8	Gujarat	9.0	Tripura	44.6
23.	Bundelkhand	49.6	Orissa Coastal	8.7	Punjab Plain	43.9
24.	Mewar	49.5	South U.P.	8.6	Orissa Coastal	43.7
25.	Dhar-Jhabua-Nimar	49.3	Konkan	8.4	Gwalior	43.5
26.	Chhota Nagpur	48.3	East U.P.	8.3	Bhopal	43.4
27.	Orissa Inland	48.2	Ajmer	8.1	Dhar-Jhabua-Nimar	43.4
28.	Orissa Coastal	47.6	Oudh	8.0	Malwa	42.9
29.	Kutch	47.3	Kutch	8.0	Orissa Inland	42.0
30.	Kangra	47.0	Kumaon-Garhwal	7.7	Jodhpur-Bikaner	41.8
31.	West Bengal*	47.0	Malwa	7.3	East U.P.	41.7
32.	Telengana	46.2	Dhar-Jhabua-Nimar	7.3	Marathwada	41.6
33.	North Bihar	45.7	Patiala	7.0	Kumaon-Garhwal	41.5
34.	Tripura	45.5	Andhra Coastal	6.6	Delhi	41.1
35.	Punjab Plain	45.5	Gwalior	5.8	West U.P.	40.9
36.	North Karnatak	45.0	Travancore-Cochin	5.8	Bundelkhand	40.9
37.	Assam Hills	44.6	Jodhpur-Bikaner	5.7	Oudh	40.5
38.	Konkan	44.2	Delhi	5.3	Patiala	40.3
39.	Coastal Andhra	44.2	Rayalaseema	5.1	South U.P.	40.1
40.	Gujarat	44.1	W. Bengal*	5.0	Telengana	39.8
41.	Travancore-Cochin	43.9	Bhopal	4.9	Mewar	39.7
42.	Mysore	43.7	Chhota Nagpur	4.7	Ajmer	39.2
43.	Bombay-Deccan	43.6	North-Bihar	4.2	Sikkim	38.9
44.	Tamilnad	42.9	South Bihar	4.2	Kangra	38.7
45.	South Bihar	42.7	Mysore	4.0	Berar-Nagpur	38.1
46.	Assam Valley	42.6	Tamilnad	3.5	Jaipur-Alwar	38.0
47.	Saurashtra	42.1	West U.P.	3.4	Jabalpur—Sagar	37.9
48.	Rayalaseema	41.8	Malabar	3.3	Kotah-Bundi	37.6
49.	Sikkim	41.7	Coorg	3.2	Calcutta Area	36.0
50.	Marathwada	41.5	Darjeeling-Duars	2.6	Chhattisgarh	34.6
51.	Malabar	41.2	Greater Bombay	2.3	Himachal	32.8
52.	Manipur	39.5	Calcutta Area	1.3	Greater Bombay	32.4

* Excluding Calcutta.

for males. The unrealistic nature of the sharp divisional differences in the 1951 Census proportions of earners and dependents becomes even clearer when we compare the figures for adjacent divisions with many similar features. Table 3 presents this comparison for three Census sub-regions. In addition to the actual percentages of SSP's, ED's and NED's to all males we have indicated the quartile rank of each percentage, that is whether it falls into the first, second, third or fourth quarter of the ranked list of divisional percentages shown in Table 2. Thus in the rolling upland tract of Chhota Nagpur where a large part of the population is tribal, the percentage of non-earners was 47, which falls into Quartile I. Just to the south, in the Chhattisgarh division, another important tribal area, the percentage of non-earners was only 35, which falls into Quartile IV. Exactly the reverse quartile relationship is shown by the respective figures for earning dependents in these two neighbouring divisions.

Sharply contrasting patterns are also to be seen among the divisions constituting the North and South Deccan sub-regions. Thus for dry inland Rayalaseema relatively low percentages (that is, in the third and fourth quartiles of all percentages) of self-supporting persons and earning dependents were accompanied by a very high percentage (in Quartile I) of non-earning dependents; in Telengana, geographically and agriculturally much the same, the proportion of earning dependents was very high (Quartile I) and that of non-earning dependents very low (Quartile IV).

Influence of exogenous factors. If we do not accept the Census of 1951 figures for self-supporting persons and earning dependents as reflections of genuine differences between one area and another, how are we to explain the observed variations? One possibility suggests itself when we group the divisions not by geographical zones

TABLE 3. PERCENTAGES OF SELF-SUPPORTING PERSONS, EARNING DEPENDENTS AND NON-EARNING DEPENDENTS TO ALL MALES IN THREE CENSUS SUB-REGIONS

		percentage of all males			quartile ranks of percentages		
		SSP	ED	NED	SSP	ED	NED
sub-region division	State*						
3.3 *North-East Plateau*							
3.31 Chhota Nagpur	Bihar	48	5	47	II	IV	I
3.32 Chhattisgarh	Madhya Pradesh	51	15	35	II	I	IV
3.33 Orissa Inland	Orissa	48	10	42	III	II	III
3.4 *North Deccan*							
3.41 Berar-Nagpur	Madhya Pradesh	50	12	38	II	I	IV
3.42 Marathwada	Hyderabad	41	17	42	IV	I	III
3.42 Bombay Deccan	Bombay	44	10	47	IV	II	II
3.5 *South Deccan*							
3.51 Telengana	Hyderabad	46	14	40	III	I	IV
3.52 North Karnatak	Bombay	45	10	45	III	II	II
3.53 Mysore	Mysore	44	4	52	IV	IV	I
3.54 Rayalaseema	Madras	42	5	53	IV	III	I

*States as of 1951.

but by census-taking jurisdictions, as in Table A. 2 in Appendix 2. In almost every case the figures for the various divisions included in a single jurisdiction (one or more States in which enumeration was under the charge of a single Superintendent) reveal striking consistencies. We see from Table 4 that in Bihar all three divisional percentages for ED's fall in the fourth Quartile, and all three percentages for NED's in the first quartile. In Madhya Pradesh, quite the other way, percentages of SSP's are uniformly in Quartile II, of ED's in Quartile I and of NED's in Quartile IV. Madras, Uttar Pradesh, and Rajasthan in turn show distinct jurisdictional patterns, each one different from the others.

It is at least arguable that differences in the recorded percentages of self-supporting persons and earning dependents reflect variations in Census administration rather than the interplay of economic factors We suggest that this may well have happened because the economic questions, instructions and illustrations as handed down from the Centre in 1951 were ill-conceived and ambiguous.

TABLE 4. QUARTILE RANKS OF DIVISIONS BY PERCENTAGES OF SELF-SUPPORTING PERSONS, EARNING DEPENDENTS AND NON-EARNING DEPENDENTS TO ALL MALES IN FIVE CENSUS JURISDICTIONS

census jurisdiction division	self-supporting persons	earning dependents	non-earning dependents
Bihar			
North Bihar	III	IV	I
South Bihar	IV	IV	I
Chhota Nagpur	II	IV	I
Madhya Pradesh			
Jabalpur-Sagar	II	I	IV
Chhattisgarh	II	I	IV
Berar-Nagpur	II	I	IV
Madras (including Coorg)			
Rayalaseema	IV	III	I
Malabar-S. Kanara	IV	IV	I
Andhra Coastal	III	III	I
Tamilnad	IV	IV	I
Coorg	I	IV	II
Rajasthan (including Ajmer)			
Jaipur-Alwar	I	II	IV
Jodhpur-Bikaner	I	III	III
Mewar	II	I	IV
Kotah-Bundi	I	II	IV
Ajmer	I	III	IV
Uttar Pradesh			
Kumaon-Garhwal	II	III	III
East U.P.	II	II	III
Oudh	II	III	III
West U.P.	I	IV	III
South U.P.	II	II	III

No satisfactory definitions of self-supporting persons or earning dependents were provided. Nor in fact could they have been provided, since the terms have little intrinsic meaning in an Indian setting. Responsibility for interpretation of these items devolved upon the State Superintendents, each of whom tried to make the best of a bad bargain.

The conceptual deficiencies of the Census of 1951 have been discussed in detail in an earlier paper prepared in this project. It may be worthwhile to quote a summary statement from that memorandum.[5]

"There were no doubt genuine economic and social differences among the States of India in 1951; but we can have no confidence that these have been accurately reflected in the Census returns...The economic categories used in the Census of 1951 were ill suited to India. It is perhaps not altogether surprising, therefore, that these categories were understood and administered differently in the various 1951 census jurisdictions."

Categories used in earlier censuses. The Census of 1951 was the third Census of India to use a three-fold economic classification. In 1931 the population had been divided into earners, working dependents and dependents. The terms used in the 1941 tables were independent persons, partly dependents, and total dependents. Prior to 1931, there were only two groups : "actual workers" and dependents. The question naturally arises as to the relationship of the three 1951 categories with the earlier sets of three categories each.

Table 5 presents for males the percentages returned under each rubric in 1931, 1941 and 1951 for five major States which were not affected by the partition

TABLE 5. PERCENTAGES OF MALES RETURNED UNDER THREE ECONOMIC CATEGORIES IN SELECTED STATES ACCORDING TO THE CENSUSES OF 1931, 1941 AND 1951

categories	1931	earners	working dependents	dependents
	1941	independent persons	partly dependents	total dependents
States	1951	self-supporting persons per 100 males	earning dependents per 100 males	non-earning dependents per 100 males
Bihar and Orissa	1931	57	1	42
	1941	51	6	43
	1951	46	6	48
Bombay	1931	50	5	45
	1941	48	8	44
	1951	46	9	45
Madras	1931	55	4	41
	1941	47	4	48
	1951	43	4	53
Uttar Pradesh	1931	63	2	35
	1941	50	4	46
	1951	53	6	41

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[5] *Comparability of Census Economic Data*, 1881–1951, Indian Statistical Institute, Bombay Branch, May 1958, paragraph 27.

of 1947. Bihar and Orissa are taken together since Orissa was not constituted as a separate State until 1936. Absolute numbers will be found in Table A.3 (Appendix 2) together with the respective figures for females and persons of both sexes. We note that in Bihar-Orissa, in Madras, and in Uttar Pradesh, the percentage of males classed in the first category (earners, independent persons, self-supporting persons) varied over a range of 10 to 13 points in the three Censuses. Differences of this order may also be observed among the several States in 1931 and 1951; the figures for independent persons and total dependents in 1941 are closer to each other. Bihar and Orissa apparently had a smaller ratio of part-earners to all males than did Madras in 1931, yet a larger ratio than Madras in 1941 and 1951. Bombay exceeded Uttar Pradesh in the proportion of non-earning males in 1931 and 1951, but the reverse was true in 1941. The trends for females are similarly erratic.

Although inconclusive, the evidence suggests that despite the superficial similarity of the names of the rubrics, the three sets of Census figures for 1931, 1941 and 1951 cannot safely be taken as counts of the same categories of persons at different points of time. It is possible that the terms used in 1931 and 1941 had, like those of 1951, different meanings in different States.

5. WORKING FORCE SIZE : EVIDENCE FROM SAMPLE SURVEYS

Let us now compare the Census data on regional variations in the size and composition of the working force with the findings of the Agricultural Labour Enquiry. Up to now we have been examining Census tabulations of SSP's, ED's and NED's in the general population, that is, the people living in both villages and towns. We shall now turn to the Census figures for the rural population, which means, in most cases, persons living in places with less than 5,000 inhabitants. Since most of the population of almost every division was rural, the All-India urban-rural ratio in 1951 being approximately 1 to 5, the percentages calculated for the rural population are very similar to those for the general population.

To obtain comparable percentages from the ALE for each division, we have taken the data for the zones or zones covering the same rural areas. Where it was necessary to combine two or, rarely, more than two ALE zones, we have simply added the figures without weighting them. It has been demonstrated that weighted and unweighted tabulations of ALE data for the Indian Union as a whole are in very close agreement.[6]

The ALE working force categories were earners (persons "who had earned income, however meagre") and helpers ("who assist earners without earning independently any income themselves"). Persons who were neither earners nor helpers were to be classed as dependents. Although these three terms are defined differently from the three terms used in the Census of 1951, a certain rough equivalence in the actual returns might reasonably have been expected. Even if the distinction between earners and helpers cannot be equated with that between SSP's and ED's, the class of dependents might be somewhat similar in scope with the NED's.

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[6] *Rural Manpower and Occupational Structure*, Ministry of Labour, Government of India, Delhi, 1954, p. 530.

Table A.4 in Appendix 2 sets out separately for males and females the Census percentages for SSP's, ED's and NED's in the rural population, together with the ALE percentages for earners, helpers and dependents. Excluding purely urban areas and tracts not covered by either the Census or the ALE, we find comparable sets of percentages for 48 divisions.

Disagreement between Census and ALE. The most striking feature of Table A.4 in Appendix 2 is that smaller percentages of dependents to all males were recorded by the ALE than by the Census in all but 6 divisions. In other words the ALE classified a much larger proportion of the rural males as either earners or helpers than the Census recorded as SSP's or ED's. Table 6 shows that whereas in 34 out of 48 Census Divisions, the composite percentage of SSP's+ED's falls below 60, all but 9 of the 48 ALE percentages of earners+helpers come to 60 or more.

With regard to the specific comparison between percentages of SSP's and percentages of earners, we note that the Census proportions are higher than those obtained by the ALE for divisions which formed part of the States of Assam, Bombay, Madhya Bharat, Punjab, Rajasthan and Uttar Pradesh. The reverse is shown by divisions which were formerly included in Madras, Hyderabad and Travancore-Cochin. Except for those divisions which belonged to Hyderabad and Madhya Pradesh, the proportion of male helpers recorded by the ALE was in every case higher than the proportion of ED's returned in the Census.

TABLE 6. FREQUENCY DISTRIBUTION OF 48 DIVISIONS BY PERCENTAGES OF *RURAL* MALES RETURNED AS EARNING OR WORKING IN CENSUS OF 1951 AND ALE

percentage of rural males earning or working	Census SSP's+ED's per 100 rural males number of divisions	ALE earners+helpers per 100 rural males number of divisions
70–74	0	1
65–69	5	11
60–64	9	27
55–59	15	8
50–54	13	1
45–49	5	0
40–44	1	0

With the ALE as well as with the Census we can discern patterns of classification which vary according to the separate States, which participated in the conduct of the survey. To bring out this character of the ALE results we have ranked the divisions twice : by percentages of SSP's and ED's in the rural population according to the Census, and by percentages of earners and helpers according to the ALE, and divided each ranked list into four quartiles. Table 7 shows the quartile rankings obtained in this manner for 19 divisions in five of the 1951 States. We note that whereas in Madhya Pradesh the Census percentages for SSP's rank in Quartile II and for ED's in Quartile I, the ALE pattern in two divisions of the three is high (I) for earners and low (IV) for helpers. In Uttar Pradesh, where the Census found relatively high percentages of SSP's and moderate percentages of ED's the ALE returns show moderate percentages of earners and fairly high percentages of helpers.

In sum the pattern of percentages obtained by the ALE was in almost every 1951 State different from the Census pattern for that State. As an indication of the degree of divergence we have calculated a product moment coefficient of correlation

TABLE 7. QUARTILE RANKS OF DIVISIONS BY PERCENTAGES OF SELF-SUPPORTING PERSONS AND EARNING DEPENDENTS TO ALL *RURAL* MALES RECORDED BY CENSUS; ALSO BY PERCENTAGES OF EARNERS AND HELPERS TO ALL MALES RECORDED BY ALE; IN FIVE STATES AS OF 1951

State division	Census		ALE	
	SSP's	ED's	earners	helpers
Bihar				
North Bihar	III	IV	II	III
South Bihar	IV	IV	II	II
Chhota Nagpur	II	IV	I	III
Madhya Pradesh				
Jabalpur-Sagar	II	I	I	IV
Chhattisgarh	II	I	II	II
Berar-Nagpur	II	I	I	IV
Madras				
Rayalaseema	IV	IV	I	III
Malabar–S. Kanara	IV	IV	II	IV
Andhra Coastal	III	III	I	IV
Tamilnad	IV	IV	I	IV
Rajasthan				
Jaipur-Alwar	I	I	IV	I
Jodhpur-Bikaner	I	III	IV	I
Mewar	II	I	III	II
Kotah-Bundi	I	II	III	II
Uttar Pradesh				
Kumaon-Garhwal	II	III	III	II
East U.P.	II	II	III	I
Oudh	I	II	II	I
West U.P.	I	IV	III	I
South U.P.	I	II	II	III

from the 48 Census percentages of SSP's+ED's to all males and the 48 ALE percentages of earners and helpers to all males. It comes to only 0.20. This would imply almost complete lack of relationship between the two sets of data, although both of them are in effect measures of the same phenomenon—the extent of working force participation in various parts of the countryside.

Comparison of rural data from three sources. By shifting from 48 divisions to 10 States, we can make a three-fold comparison of Census, ALE and National Sample Survey (NSS) results relating to rural areas. We use the NSS data for earners and earning dependents rather than the NSS figures for persons in the labour force (gainfully employed plus unemployed), since the former were intended specifically to be comparable with the Census SSP's and ED's. In the NSS instructions, the category of earning dependents was defined explicitly to include unpaid family helpers.

A full comparison of the percentages obtained for rural males and females of all three categories by the three different sources is presented in Appendix 2, Table A.5. In most States the NSS figures for male earners are higher than the respective Census and ALE figures. The NSS figures for male ED's are, however, generally lower than the ALE figures for male helpers. With regard to dependents, the NSS proportions for males are closer to those of the ALE than to those of the Census.

Extent of agreement between NSS and ALE. In other words the NSS, like the ALE, identified a larger segment of the rural population as earners or workers than did the Census. We can state the position more exactly if we set out the percentages obtained for rural males in each State together with the percentages of rural males in the working ages (15 to 64). Table 8 shows that, with a single exception, both the ALE and the NSS classed in one or another of their working force categories at least as large a proportion of all males as would be accounted for by the men from the ages of 15 through 64. In other words, the data from both sample surveys would suggest that in most States, not only the whole or practically the whole number of adult males in their prime, but also a fraction of boys under 15 and elderly men were working. The Census ratio of SSP's and ED's to all males, by contrast, equals or exceeds the ratio of working-age men to all rural males in only three States: Uttar Pradesh, Madhya Pradesh, and Punjab. By the same token the Census working force measure approaches that of the other two surveys only in these three cases. The extent of agreement between the ALE and the NSS findings is larger than that between either of these surveys and the Census. In fact, the returns from ALE and NSS for Madras, Orissa, Madhya Pradesh, Bombay and Assam are practically identical, while the discrepancies in the case of West Bengal and Andhra are small. But the two surveys fail to agree in respect of Uttar Pradesh, Bihar and Punjab.

We have previously noted the strong influence of State boundaries on the pattern of ALE percentages of earners, helpers and dependents. Nonetheless, we cannot ignore the marked consistency of the NSS and ALE findings for the rural male working force as a whole in 7 out of 10 States. The fact that the range of variation from State to State recorded by the ALE and NSS is narrower than that of the

Census in itself lends credence to the results of the two surveys. Whereas it is impossible to establish any meaningful relationship between age structure and the Census working force participation data, we may observe that in 7 States the figures for workers according to both surveys exceed the figures for males in the age group 15-64 by at least two percentage points.

Dimensions of rural working force. The concurrence of the two surveys in these several respects suggests that the overall dimensions of the rural male working force in the early 1950's may be more accurately reflected by the surveys than by the Census. If this is the case, we could say tentatively that rural Andhra, Madras and Orissa were characterized by relatively high proportions of male workers as well as of males in the working ages. In the villages of Madhya Pradesh and Assam the proportion of workers compared even more favourably with that of the men from 15 to 64. In Bombay a relatively low percentage of male workers went along with a relatively low percentage of working-age males.

TABLE 8. PERCENTAGES OF EARNERS TO ALL *RURAL* MALES RECORDED BY CENSUS, ALE AND NSS IN 10 STATES (AS OF 1951)

States	men in age group 15—64 per 100 rural males	Census	ALE	NSS-9th round
		SSP's+ED's per 100 rural males	earners+helpers per 100 rural males	earners+ED's per 100 rural males
West Bengal	61	52	62	59
Andhra	61	50	64	67
Madras	60	45	63	62
Orissa	59	57	63	62
Uttar Pradesh	58	60	64	58
Madhya Pradesh	58	65	64	63
Bihar	56	50	64	56
Bombay	56	54	59	58
Assam	55	54	60	61
Punjab	54	57	62	57
high	61	65	64	67
low	54	45	59	56
range	7	20	5	11

All of these conclusions are, of course, highly tentative. They refer solely to the figures for the total number of men counted as working and leave altogether out of consideration any distinction between earners and helpers or earners and ED's. The implication would be that the Census of 1951 under-enumerated the rural male working force in most of India, particularly in the areas which were included in the State of Madras, and to a lesser extent in Assam, Bihar, Bombay, Orissa and West Bengal.

Dimensions of urban working force. With regard to urban workers, we can compare the Census data only with those of the NSS. Full details for both sexes are to be found in Appendix 2, Table A.6. In West Bengal, Bombay, Uttar Pradesh and Assam the Census percentages for SSP's to all males exceed the NSS percentages for earners. In Orissa, Madhya Pradesh and Punjab, the Census proportions of male ED's are higher than the respective NSS proportions. To our surprise we find in Table 9 that for each one of the seven States just named the total Census figure for SSP's plus ED's is greater than the NSS figures for earners plus ED's. Only in Madras, Andhra and Bihar did the NSS find a larger percentage of urban males working than did the Census. In every State the percentage of urban males classed as earning by the NSS as well as by the Census was less—typically much less—than the percentage in the working ages.

TABLE 9. PERCENTAGE OF EARNERS TO ALL *URBAN* MALES AS RECORDED BY CENSUS AND NSS IN 10 STATES (AS OF 1951)

States	men in age group 15-64 per 100 urban males	census	NSS 9th round
		SSP's+ED's per 100 urban males	earners+ED's per 100 urban males
West Bengal	72	61	60
Assam	66	54	50
Bombay	65	57	55
Madras	63	49	53
Uttar Pradesh	62	56	54
Andhra	61	50	59
Madhya Pradesh	61	55	52
Bihar	61	48	56
Orissa	61	57	56
Punjab	58	54	50
high	72	61	60
low	58	49	50
range	14	12	10

It may also be noted that the Census percentage of workers among rural males equalled or exceeded the percentage for urban males in all but three States. In these States—West Bengal, Bombay and Madras—were located the great cities of Calcutta, Bombay and Madras. This aspect of the Census findings is supported by the trend in the NSS percentages of earners and earning dependents to all males for three strata of urban blocks. Thus 60 of every 100 males were classed as earning in stratum 1 consisting of blocks in Calcutta, Bombay, Madras and Delhi, while only 54 of every 100 were so classed in strata 2 and 3, representing smaller cities and towns.[7]

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[7] National Sample Survey: Number 16, *Employment and Unemployment:* Ninth Round Preliminary, May–November 1955, p.199.

Confirmation of this kind is, however, suggestive rather than definitive. The available materials do not permit a positive statement as to whether the urban working force data collected by the Census of 1951 are in whole or in part more reliable than the rural.

One conclusion which is strongly suggested by the data we have examined is that attempts to enumerate two classes of workers—e.g., self-supporting persons and earning dependents; independent persons and partly dependents; earners and helpers—have proved unrewarding.

6. OCCUPATIONAL STRUCTURE OF WORKING FORCE

Nature of occupational breakdown. In the analysis of occupational distribution, we have found it practicable to take account specifically of only three categories: owner cultivation, tenant cultivation and agricultural labour. All other kinds of work have been treated together under the broad and not quite accurate head of "non-agriculture". We have been constrained to employ this particular breakdown by the way in which the Census of 1951 occupational data were treated. Although the returns for principal "means of livelihood" of self-supporting persons were sorted and tabulated under approximately 100 rubrics, the work of earning dependents was set out only in terms of eight "livelihood classes". Similarly, data on secondary employment of self-supporting persons was presented only by livelihood classes.

Of these eight "livelihood classes", two were reserved for cultivators (of mainly owned land and of mainly unowned land, i.e., owners and tenants), one for agricultural labourers, one for non-cultivating receivers of agricultural rent, and the remaining four for occupations in all industries other than cultivation. The four "non-agricultural" classes varied widely in the range of industrial and occupational groupings which they included. Class V, Production, lumped together livestock keeping, plantation industries, hunting, fishing and forestry (usually treated in conjunction with, if not as part of, agriculture) with all extractive, processing, and manufacturing industries. Class VI, Commerce, was restricted, as in standard usage, to wholesale and ratail trade, banking, insurance, and real estate. Class VII, Transport, was severely limited to carriers by road, rail, sea and air. It excluded storage, warehousing, postal, telephone and telegraph services. Class VIII, by contrast, represented a catch-all category for construction, utilities, communications, public administration, domestic and all other services. Into this class were also thrown persons dependent on unproductive sources of livelihood such as income from investments or begging. In sum, the four "non-agricultural" classes were neither occupational, nor industrial, nor socio-economic groupings.

It seemed to us that no purpose would be served in perpetuating this anomalous set of rubrics. On the other hand, no more detailed breakdowns were available for the sector of the working population returned as earning dependents or for the secondary occupations of "self-supporting persons". It was not possible to extract from the Census even approximate figures to compare with the two-fold ALE classification of all occupations apart from the land into "non-agricultural labour" and "other non-agricultural work".

Distinction between owners and tenants. A further problem arose in the classification of cultivators with regard to landholding status since the lines of demarcation between owners and tenants were differently drawn. The Census took as owners all tenants with permanent heritable occupancy rights, with or without right of unrestricted transfer. The Agricultural Labour Enquiry, by contrast, considered as owners only persons holding directly from Government. We shall note the effects of this conceptual difference on the percentages of owners and tenants shown in the two sets of findings.

The first of the occupational tables, Table A.8 in Appendix 2 shows for the general population (rural plus urban) of each Census division the proportions of earners (self-supporting persons plus earning dependents of both sexes) returned in the Census as owner-cultivators, tenant-cultivators, cultivating labourers, and rent receivers. All other occupations are grouped, as we have explained, in a residual category which may very roughly be considered as non-agricultural. It must be kept in mind that this category includes plantation work, livestock keeping, forestry and fishing as well as genuinely non-agricultural activities. In every case, earning dependents have been assigned to the occupation in which they themselves were active rather than (as in the main Census tables) the occupation of the person upon whom they were returned as partly dependent.

Using as the primary criterion the percentage of workers in non-agriculture we have sorted the 52 divisions into three broad classes : A—divisions with diversified economies, B—mainly agricultural divisions, and C—preponderantly agricultural divisions. Within the first class, we have distinguished two sub-classes on the same basis: relative prevalence of workers in non-agriculture. Within the second and third classes, we have distinguished three sub-classes each in accordance with the prevalence of cultivating labourers or, conversely, of owner and tenant cultivators. We have set out no comparison of divisions in respect of the percentages of persons returned as non-cultivating rent receivers since these were in almost all cases extremely small. Table 10 shows the grouping of the divisions into these classes and sub-classes.

Factors affecting occupational percentages. In so far as concerns the various percentages recorded for owner-cultivators and tenant-cultivators, it must be kept in mind that the Census of 1951 did not use these terms in the way they are normally understood. According to the instructions, all tenants with permanent or heritable possession were to be taken as owners, whether or not they had the right of transfer. As for cropsharers, no all-India directions were issued as to whether or not they were to be classed as tenants. In the result, it appears that the line dividing owners from

TABLE 10. GROUPING OF 52 DIVISIONS ACCORDING TO PERCENTAGES OF SELF-SUPPORTING PERSONS AND EARNING DEPENDENTS (BOTH SEXES) RETURNED IN THE CENSUS OF 1951 AS WORKERS IN NON-AGRICULTURE (INCLUDING PLANTATIONS), AND AS AGRICULTURAL LABOURERS

divisions	percentage of workers in non-agriculture	percentage of agricultural labourers	percentage of tenant cultivators	percentage of owner cultivators	percentage of all cultivators
A : divisions with diversified economies					
1. *highly urbanized*					
Greater Bombay	99.4	0.1	0.1	0.1	0.2
Delhi	90.1	2.2	0.6	6.6	7.2
Chandernagore	94.4	—	—	—	—
2. *relatively diversified*					
Darjeeling-Duars	57.7	3.9	17.4	20.2	37.6
Coorg	56.5	12.0	6.5	18.5	25.0
Kutch	54.5	12.8	7.4	24.0	31.4
Travancore-Cochin	51.7	23.9	5.1	18.3	23.4
West Bengal Plain	51.7	16.2	8.9	22.8	31.7
Malabar	51.4	24.1	16.6	5.9	22.5
Ajmer	44.9	17.6	3.2	32.5	35.7
Saurashtra	44.0	15.9	7.4	31.5	38.9
B : mainly agricultural divisions					
3. *significant use of hired labourers*					
Bhopal	33.1	25.6	7.2	32.0	39.2
Telengana	32.4	35.7	5.4	25.5	30.9
Malwa	30.9	25.1	9.0	34.2	43.2
Coastal Andhra	30.7	31.5	6.1	29.9	36.0
Jabalpur-Sagar	25.5	41.7	2.7	29.3	32.0
4. *moderate use of hired labourers*					
Tamilnad	38.1	21.5	6.9	31.9	38.8
Rayalaseema	35.5	19.4	4.3	38.8	43.1
Coastal Orissa	34.5	14.6	7.0	42.3	49.3
Gujarat	34.0	18.8	8.3	37.6	45.9
Inland Orissa	27.2	20.5	3.5	48.2	51.7
Deccan	27.1	20.5	4.1	47.2	51.3
5. *chiefly owner and tenant farming*					
Assam Valley	39.3	3.1	12.6	44.5	57.1
Manipur	36.9	0.0	7.6	53.5	61.1
Punjab Plain	36.8	12.0	14.8	34.1	48.9
Mysore	35.9	10.0	4.9	46.9	51.8
West Uttar Pradesh	34.6	5.8	3.5	54.9	58.4
Konkan	31.7	11.0	30.0	26.6	56.6
Tripura	28.6	9.1	8.3	52.5	60.8
Gwalior	28.0	7.8	17.2	45.5	62.7
Jaipur-Alwar	27.9	7.0	21.1	42.9	64.0
Patiala	27.1	10.6	11.4	48.8	60.2
Jodhpur-Bikaner	26.4	4.9	43.9	24.1	68.0
Kotah-Bundi	25.8	13.0	2.6	56.8	59.4

TABLE 10. GROUPING OF 52 DIVISIONS ACCORDING TO PERCENTAGES OF SELF-SUPPORTING PERSONS AND EARNING DEPENDENTS (BOTH SEXES) RETURNED IN THE CENSUS 1951 AS WORKERS IN NON-AGRICULTURE (INCLUDINGPLANTATIONS), AND AS AGRICULTURAL LABOURERS (*concluded*)

divisions	percentage of workers in non-agriculture	percentage of agri-cultural labourers	percentage of tenant cultivators	percentage of owner cultivators	percentage of all cultivators
C : preponderantly agricultural divisions					
6. *cultivation largely through hired labour*					
Marathwada	23.5	38.5	4.6	31.7	36.3
Berar-Nagpur	22.6	58.3	3.7	14.4	18.1
Chhattisgarh	18.1	41.0	2.0	38.4	40.4
Sikkim	10.1	48.1	6.3	34.2	40.5
7. *self-cultivation plus hired labour*					
North Karnatak	23.9	24.9	10.7	38.8	49.5
South Uttar Pradesh	23.7	14.4	6.8	54.1	60.9
South Bihar	21.5	23.4	7.6	46.2	53.8
Dhar-Jhabua-Nimar	16.8	23.8	7.9	50.8	58.7
Bundelkhand	15.5	23.3	6.1	54.5	60.6
North Bihar	11.4	31.6	11.8	44.5	56.3
8. *ownership cultivation predominant*					
Oudh (Central U.P.)	24.2	6.9	5.8	62.2	68.0
Punjab Hills	22.3	4.5	14.6	57.1	71.7
Mewar	21.7	5.6	5.4	66.5	71.9
Chhota Nagpur	17.9	10.9	3.0	67.8	70.8
Kumaon-Garhwal	17.7	1.4	4.8	76.0	80.8
East Uttar Pradesh	17.3	9.2	6.5	66.5	73.0
Assam Hills	16.5	4.3	3.8	74.6	78.4
Himachal	10.4	2.6	6.6	79.9	86.5

tenants was drawn differently in different States, and that cropsharers were recorded as tenants in some States but not in others. Although we have calculated separately the percentages of owners and tenants, we do not attach much significance to the distinction.

Another caution must be sounded. It will be recalled that the percentages of self-supporting persons and earning dependents recorded in the various census divisions differed widely from each other. Thus 60 percent of all persons (males and females) in Chhattisgarh and Himachal divisions were returned as earners, but only 30 percent of all persons in Tamilnad, Malabar and the old Mysore State. As we have pointed out, it is extremely unlikely that the true variation in the proportions of workers in different areas should be of this magnitude. We have presented arguments to the effect that the higher figures are more likely to be reliable, and that the lower ones represent serious under-enumeration of the labour force.

It appears probable that the persons whose work activity was not recorded in the Census of 1951 were in large part family helpers in cultivation or persons working irregularly as farm labourers. Where enumeration of the working force has been fairly complete, the percentage of workers engaged in cultivation and agricultural labour may be presumed to be reasonably accurate. Where the working force has been under-counted, we may guess that the percentages of persons engaged in agricultural pursuits should really be higher and, as a result, the percentage of non-agricultural workers should really be lower. Thus it may be noted that if figures were available for the entire working population of Travancore-Cochin and Malabar (rather than for what may be only one-half to two-thirds of the full number), the degree of economic diversification shown in these two divisions might be somewhat less marked. Similarly, Oudh and South Uttar Pradesh, both of which can boast of several good-sized cities with some industrial development, would presumably rank by comparison as less preponderantly agricultural, if a full count of cultivators and labourers had been taken in such divisions as Mysore and Rayalaseema.

One more factor affecting the percentages is the size of the unit for which they are calculated. Since each State which existed in 1951 was taken as a separate division, a few divisions such as Kutch, Coorg, Ajmer, Manipur, Tripura and Chandernagore are extremely small. In these cases, the existence of a single town with its inevitable array of urban occupations may be enough to over-balance the pattern of the area in which the town is situated. Hence the high proportions of non-agricultural workers in Ajmer and Coorg.

Regional variation in occupational structure. Observing all of these precautions, it is nonetheless possible to make a few generalizations about the distribution of the major divisions by economic type, according to the Census occupational data. Apart from the great urban centres of Calcutta, Bombay and Delhi, relatively high percentages—ranging from 44 to 58—of "non-agricultural" workers were found in plantation areas (Darjeeling-Duars and Coorg) or in coastal tracts with a long commercial tradition (Saurashtra and Kutch). Malabar and Travancore-Cochin fit both of these descriptions.

Among the large number of divisions in which the working population was mainly, although not overwhelmingly, engaged in agricultural pursuits (i.e., with 25 to 40 percent engaged in non-agricultural), Bhopal, Telengana, Malwa, Coastal Andhra and Jabalpur-Sagar divisions stand out with 26 to 33 percent of all earners returned as cultivating labourers. This would suggest larger holdings or an important degree of commercial agriculture, or both.

Tamilnad, Rayalaseema, Coastal and Inland Orissa, Gujarat, and Deccan comprised another group of mainly but not preponderantly agricultural regions. These divisions are not readily characterized since the percentages of workers in non-agriculture, cultivating labourers, and cultivating owner or tenant holders were all intermediate. Nor is it necessarily the case that the constellation of percentages has the same significance in one division as in another. A relatively high percentage of non-agricultural workers in a backward tract such as Inland Orissa may have reflected primarily the low productivity of agriculture. The picture was of course quite different in Gujarat with its business-like farmers and important textile industry.

In the third sub-class of divisions where non-agriculture accounted for one-quarter to two-fifths of the working force, self-cultivation by owners and tenants was more typical than use of hired labour. This group included a fairly large block of divisions in North and North-West India : West Uttar Pradesh, Gwalior, Jaipur-Alwar, Kotah-Bundi, Jodhpur-Bikaner, Punjab Plain and Patiala and, from further south, Mysore and the Konkan. In Assam Valley, "non-agriculture" consisted to an important degree in plantation work. Substantial proportions of tenants were returned among the cultivators in Jodhpur-Bikaner, Jaipur-Alwar, and the Konkan.

In the eighteen remaining divisions, agriculture supplied the occupation for three-quarters or more of the working force. It may be noted that these are all inland areas. Large concentrations of hired labourers characterized farm operations in the sub-class comprising Marathwada, Berar-Nagpur, Chhattisgarh and Sikkim Divisions. A combination of self-cultivation, primarily by owners, with some use of hired labour was found in the preponderantly agricultural divisions of North and South Bihar, South Uttar Pradesh, Bundelkhand, Dhar-Jhabua-Nimar, and North Karnatak. The final sub-class consisted, apart from East and Central Uttar Pradesh, of hilly and peripheral tracts where a small percentage of non-agricultural workers went along with a high percentage of cultivating owners. In this group were Assam Hills, Punjab Hills, Himachal, Kumaon-Garhwal, Chhota Nagpur and Mewar. Relative inaccessibility perhaps helped to insulate these areas against the spread of tenancy, cultivation through hired labour, and economic diversification.

Census and ALE data on rural occupational distribution. So far we have been considering the occupational distribution of the general population, that is of all workers whether in villages or in towns, in order to obtain an overall view of the economic structure of the various divisions. Let us now turn our attention to the rural working force, data which is available from the ALE as well as from the Census. Since the ALE presented no direct occupational information on helpers, we have taken ALE figures for earners and Census figures for self-supporting persons. Territorially, the ALE occupational data have been given for entire States rather than for zones within each State. Accordingly we have set out the comparison in terms of the 17 major States as they were constituted in 1951. The respective percentages of Census SSP's and ALE earners in cultivation, agricultural labour and other occupations are shown in Table 9 in the Appendix.

Many differences between the ALE occupational findings and the Census results are immediately apparent. In almost every State, the percentage of agricultural labourers found by ALE is much greater than that found by the Census. On the other hand, the percentages of owners recorded by the ALE are consistently and strikingly less than those reported in the Census. The proportion of tenants is in some cases greater and some smaller. The same is true of the percentage of workers in non-agriculture.

Conceptual differences. These discrepancies may be ascribed in the first place to the difference in the definitions of owner and tenant to which we have already referred, and to the broader conception by the ALE of the class of labourers. In responding to the Census enumerator, a petty cultivator who also hired out regularly as a field labourer was free to describe himself as primarily an owner or a tenant. The ALE investigators, by contrast, were instructed to record as a labourer anyone who, they ascertained, had spent more than half of his working days during the past year in that capacity, whether or not he also cultivated on his own account.

We may also recall that in almost every division the percentages of males and females returned as earners in the ALE differed from the percentages returned as SSP's in the Census. Proportions returned in particular occupations may well be affected by variations in the size and composition of the group taken as the base. For example, in a particular division the Census may show a larger percentage of persons engaged in non-agriculture than the ALE because a substantial number of women who work as agricultural labourers have been returned by their husbands as non-earning dependents. Or the ALE may arrive at a higher percentage of cultivators than the Census because it has counted as earners a considerable number of persons who help only from time to time in the cultivation of family land.

Relative prevalence of cultivators and agricultural labourers. Nonetheless, taking the whole array of percentages together and considering not so much the *actual* figures as the *relative* position of each State, we discover an important area of agreement between the Census and the ALE. Table 11 shows the respective rank orders of the States by proportions of cultivators and proportions of agricultural labourers.

TABLE 11. RANKING OF 17 STATES (AS OF 1951) BY PERCENTAGES OF CULTIVATORS AND AGRICULTURAL LABOURERS AMONG ALL *RURAL* WORKERS ACCORDING TO CENSUS AND ALE

rank order	owners and tenants		agricultural labourers	
	census	ALE	census	ALE
1	Rajasthan	Rajasthan	Madhya Pradesh	Madras
2	Uttar Pradesh	Assam	Travancore-Cochin	Hyderabad
3	Vindhya-Pradesh	Uttar Pradesh	Madras	Madhya Pradesh
4	Mysore	PEPSU	Hyderabad	Mysore
5	PEPSU	Bombay	Bihar	Orissa
6	Punjab	Vindhya Pradesh	Vindhya Pradesh	Bihar
7	Bihar	Madhya Bharat	West Bengal	Travancore Cochin
8	Bombay	Punjab	Orissa	Saurashtra
9	Orissa	West Bengal	Bombay	Madhya Bharat
10	Assam	Mysore	Madhya Bharat	Bombay
11	Saurashtra	Saurashtra	PEPSU	Vindhya Pradesh
12	Madhya Bharat	Madhya Pradesh	Mysore	West Bengal
13	Madhya Pradesh	Orissa	Punjab	Uttar Pradesh
14	Hyderabad	Bihar	Uttar Pradesh	PEPSU
15	Madras	Hyderabad	Saurashtra	Rajasthan
16	West Bengal	Madras	Rajasthan	Assam
17	Travancore-Cochin	Travancore-Cochin	Assam	Punjab
	highest 80 percent	66 percent	29 percent	61 percent
	lowest 31 percent	15 percent	2 percent	11 percent

It becomes clear that relatively high percentages of cultivators were recorded in the rural tracts of Rajasthan, Uttar Pradesh, Vindhya Pradesh (Bundelkhand), PEPSU (Patiala), and Punjab by both the Census and the ALE. Relatively low percentages of agricultural labourers were found in both cases in Rajasthan, Uttar Pradesh, PEPSU, Punjab and Assam. A quite different economic picture—low percentages of cultivators and high proportions of labourers—was indicated by both Census and ALE in Madhya Pradesh, Hyderabad, Madras, and Travancore-Cochin.

Both sources also showed concentration of agricultural labourers in Bihar, although the ranking by percentage of cultivators was disparate. Again both showed a relatively low proportion of cultivators in Saurashtra, accompanied by a high percentage of non-agricultural workers. Census as well as ALE figures for Bombay, Orissa and Madhya Bharat are intermediate. Sharp disagreement is registered with regard to Mysore where the Census found a high proportion of cultivators and the ALE a high proportion of labourers. On the whole, the occupational distribution of ALE earners tends to support the Census evidence that cultivation by owners and tenants prevailed in the greater part of north and north-west India, while agricultural labour had its chief economic importance in south and central India.

Distribution unaffected by inclusion of secondary occupations. If we take account of secondary as well as principal occupations of Census SSP's and ALE earners in these same seventeen States, the picture remains substantially unchanged. Table A.10 in Appendix 2 allows us to compare the *total* importance of each of the three occupational categories: cultivation, agricultural labour, and non-agriculture, by taking account of *all* workers in each category whether it is their sole occupation or only one of two occupations. In this way we can assess the full strength of the working population engaged in cultivation of land or the maximum extent of the hired agricultural labour force. The *total* percentages, of course, add up to more than 100 percent since each person with two occupations is included twice.

In constructing this table we have taken cultivation as a single occupation, regardless of whether the cultivator has been returned as an owner or tenant. Persons appearing in Census and ALE tabulations as primarily cultivating owners with a secondary occupation as cultivating tenants or vice versa (cultivating tenants with a secondary occupation as cultivating owners), we have treated uniformly as cultivators with no subsidiary work. Similarly, for persons returned in the Census as primarily subsisting on receipt of rents but having a secondary economic activity or vice versa, we have taken the actual work as the sole occupation. For these reasons, our final figures for the percentages of workers who have more than one occupation are somewhat less than the published Census and ALE figures. Although the ALE figures refer to the rural area, we have had to use Census data for the general population (rural plus urban), since Census information on secondary occupations was not tabulated separately for urban and rural areas.

The ALE percentages for earners with more than one occupation run consistently higher than the Census figures. But this might well be the result of the more intensive questioning which is possible in a sample survey and not in a general population census. Whereas the Census percentages for the 17 States range from 2.6 percent in Saurashtra to 22.6 percent in Orissa, the ALE figures vary from 9.3 percent for PEPSU to 47.4 percent for Bihar. Census and ALE both found low percentages of workers engaged in two occupations in PEPSU, and high percentages in Orissa. But sharp disagreement may be noted between the Census and ALE percentages for Bihar and Saurashtra.

When we look at the figures for the *total* percentage under each occupation, we find once again that Rajasthan, Uttar Pradesh, Vindhya Pradesh and PEPSU rank high in proportion of cultivators while Saurashtra, Madhya Pradesh, Hyderabad, Madras and Travancore-Cochin rank low. As before, agricultural labour looms large in the last-mentioned four States plus Bihar, but is relatively minor in Rajasthan, Uttar Pradesh, PEPSU, Punjab and Assam. Despite the varying proportions of workers for whom a second occupation was recorded by the Census and the ALE, there is clear agreement on the relative positions of the seventeen States with regard to the *total* strength of the three types of work.

Differing proportions of agricultural labourers. In the discussion of distribution by principal occupation we noted that in practically all States the ALE identified a much greater proportion of the working force as agricultural labourers than the Census. We attributed these discrepancies primarily to differences in definition To our surprise, it appears that even when secondary occupations are taken into account the ALE percentages for agricultural labourers are twice or more than twice the Census percentages in 11 of the 17 States. This is the case in States with relatively high percentages of labourers according to both sources (e.g. Hyderabad and Madras) as well as in States where both Census and ALE found relatively low percentages of labourers (e.g. Uttar Pradesh and Rajasthan). We shall return to this topic after considering the ALE data on landholding by agricultural labour families.

7. OCCUPATIONAL DEPENDENCE OF THE ENTIRE POPULATION

Distribution by occupation of head of household. It is possible to classify the entire population, non-workers as well as workers, by the occupations upon which they depend for their livelihood. In effect this amounts to a classification of all household members by the type of work done by the head of the household. We have used this method despite its somewhat crude nature, because it bypasses the problem of differences from State to State in the proportion of persons classed as earners or workers. An additional advantage is that we are able to prepare distributions of this nature from the ALE for the rural population of 48 divisions.

From the Census we have calculated percentages in agriculture, agricultural labour, etc., by using the total numbers of persons returned under one or another of the eight Livelihood Classes. From the ALE we have used the total numbers of persons in families assigned to one or another occupational group. Each Census Livelihood Class consisted of all self-supporting persons in a particular occupational category—

such as cultivating owners—and all earning or non-earning dependents who derived partial or full support from these self-supporting persons. In the great majority of cases only a single self-supporting person was returned for each household. Other working members, if any, were typically taken as earning dependents. Thus, whether or not their own work was the same as that of the head of the household, they were automatically assigned to his livelihood class. Only if a member of the household other than the head were returned as a self-supporting person and if this person's work fell into a different occupational category would he be assigned to a different livelihood class. Thus distribution of population by livelihood classes is roughly equivalent to distribution of population on the basis of the principal occupation of the head of the household.

Similarly, for the Agricultural Labour Enquiry, the family occupation appears to have been determined primarily by the principal employment of the head of the family. The only exception to this practice which is specifically mentioned is that families in which the majority of the earners were agricultural labourers were classed as agricultural labour families even if the head himself had a different occupation. However, it seems unlikely that this could have affected the classification of any significant number of persons.

Apparent contrast between Census and ALE results. Table A.11 in Appendix 2 presents for the rural population of 48 divisions the respective Census and ALE proportions of persons in families of owners, tenants, agricultural labourers and workers in all other occupations. At first glance the percentages calculated from the two sets of data for each of these categories appear to follow altogether different patterns. For example, in the rural areas of Coastal Andhra the Census found half of the population to belong to families of owners and tenants, and only about one-quarter to families of agricultural labourers. The respective ALE percentages are almost exactly the reverse.

But it is possible to put together a composite figure for all persons in landholding families which includes non-cultivating landholders (who were separately tabulated in the Census) and agricultural labour families with land (which were separately tabulated by the ALE). When compiled in this fashion, the Census and ALE proportions for landholders in Coastal Andhra (54.3 and 55.5 respectively) are almost identical. The same striking concurrence may be noted in the Census and ALE figures for the percentage of landholders and their families in the rural population of the other two divisions now included in the State of Andhra: Telengana (58.6 and 60.7) and Rayalaseema (61.7 and 64.3). In fact, Census and ALE figures run closely parallel in about half of the divisions. Even where the actual numbers differ, the relative position of the various divisions according to both Census and ALE tends to agree. The product moment correlation for ratio of persons in landholding families to all persons according to Census and according to ALE is .729.

With regard to the percentage of the population dependent upon agricultural labour, the ALE figures are for most divisions approximately twice as high as the Census figures. Nonetheless, there is mutual confirmation as to the relative ranking of divisions by prevalence of agricultural labour as a means of subsistence. For example, Berar-Nagpur has the highest proportion of persons dependent on agricultural labour according to both Census and ALE, but the respective figures are 38.4 percent and 57.6 percent. The product moment correlation between the two sets of percentages under the rubric agricultural labour is .738. Much less agreement is exhibited in respect of the proportions of the population whose support is attributed to non-agriculture, the correlation in this case amounting only to .572.

Significance of landholding by agricultural labour families. We note with interest that for Berar-Nagpur the ALE percentage for persons in agricultural labour families *without land* is 38.3; in other words, it is practically identical with the Census percentage of 38.4 for all persons in the agricultural labour class. The same phenomenon may be observed for Coastal Andhra where the ALE percentage for dependence on landless agricultural labour is 26.5 and the Census figure for all agricultural labour is 25.7. Reasonably close agreement of these two scores (within a range of five percentage points) is found in 33 of the 48 divisions. It would appear that in most parts of India only persons who had no land of their own tended to return themselves in the Census as agricultural labourers. By contrast, the ALE included in its count large numbers of petty cultivators for whom agricultural labour provided an additional source of employment and income. Roughly, the Census and ALE percentages for each division may be taken as indicating the range from the proportion of the working force dependent almost exclusively upon opportunities for paid agricultural labour to the proportion available from time to time for hire as field labourers.

The implications of the high correlations between the Census and the ALE on the relative importance of landholding and agricultural labour can be brought out by a comparison of quartile rankings of the four percentages for each division. This procedure will also allow us to make tentative statements about the economic structure of the rural areas of those divisions for which the Census and ALE data fall into the same pattern.

Regional patterns of occupational dependence. Table 12 shows the respective quartile ranking of the divisions by percentage of *rural* persons in landholding classes and percentage in agricultural labour class according to, first, the Census and, second, the ALE. The substantial agreement between the two sets of data on the characteristic patterns of divisions and groups of divisions is immediately apparent. We see at once that all three divisions in Andhra have low scores for landholders and high scores for agricultural labour. A similar pattern can be observed in the quartiles for North Bihar, Berar-Nagpur and Marathwada divisions of Maharashtra; both parts of Kerala; Bhopal, Jabalpur-Sagar and Malwa divisions of Madhya Pradesh; Tamilnad, and the West Bengal Plain. Agricultural labour percentages in the upper quartiles

TABLE 12. QUARTILE RANKS OF DIVISIONS BY PERCENTAGE OF *RURAL* POPULATION IN LANDHOLDING CLASSES (OR FAMILIES) AND AGRICULTURAL LABOUR CLASS (OR FAMILIES), ACCORDING TO CENSUS OF 1951 AND ALE

State	division	census		ALE	
		quartile rank by percentage in landholding class	quartile rank by percentage in cultivating labour class	quartile rank by percentage in landholding families	quartile rank by percentage in agricultural labour families
Andhra	Coastal Andhra	IV	I	IV	I
	Telengana	IV	I	IV	I
	Rayalaseema	III	II	III	I
Assam	Assam Valley	II	IV	I	IV
	Assam Hills	I	IV	II	IV
	Manipur	I	IV	I	IV
	Tripura	II	III	I	III
Bihar	North Bihar	III	I	III	II
	South Bihar	III	I	II	II
	Chhota Nagpur	I	III	III	I
Gujarat	Gujarat	III	III	III	III
	Saurashtra	III	III	IV	III
	Kutch	IV	IV	IV	III
Kerala	Travancore-Cochin	IV	I	IV	I
	Malabar	IV	I	IV	I
Madhya Pradesh	Gwalior	I	IV	I	IV
	Malwa	III	II	III	II
	Dhar-Jhabua-Nimar	II	II	III	II
	Bhopal	IV	I	IV	I
	Jabalpur-Sagar	III	I	IV	II
	Chhattisgarh	III	II	II	II
	Bundelkhand	II	I	I	III
Madras	Tamilnad	IV	I	III	I
Maharashtra	Konkan	II	III	I	II
	Deccan	II	II	I	II
	Berar-Nagpur	IV	I	IV	I
	Marathwada	III	I	III	I
Mysore	Old Mysore	I	III	II	I
	Coorg	IV	II	II	III
	North Karnatak	III	II	I	II
Orissa	Coastal Orissa	III	II	II	II
	Inland Orissa	II	II	III	I
Punjab	Punjab Plain	III	III	III	IV
	Patiala	II	II	III	III
	Delhi	IV	III	IV	IV
	Himachal	I	IV	II	IV
Rajasthan	Jaipur-Alwar	I	IV	II	IV
	Ajmer	II	IV	II	IV
	Jodhpur-Bikaner	I	IV	I	IV
	Mewar	I	IV	I	IV
	Kotah-Bundi	II	III	II	III
Uttar Pradesh	Kumaon-Garhwal	I	IV	I	IV
	East U.P.	I	III	II	III
	Oudh	I	III	II	III
	West U.P.	II	III	III	III
	South U.P.	II	II	IV	III
West Bengal	Darjeeling-Duars	IV	IV	I	II
	W. Bengal Plain	IV	II	IV	II

according to both Census and ALE are also to be found in South Bihar, both tracts of Orissa, Deccan, North-Karnatak, Dhar-Jhabua-Nimar and Chhattisgarh.

Rural Assam shows an altogether contrasting configuration : high percentages of landholders and low percentages of labourers. Other divisions of this type are Gwalior, Himachal Pradesh, Kumaon-Garhwal, East Uttar Pradesh, Oudh, and all of Rajasthan. High proportions of landholders were also recorded in Konkan. Gujarat occupied a median position with regard both to landholders and to agricultural labourers. Conflicting patterns in respect of landholders and labourers are presented by the Census and ALE data for Chhota Nagpur, Bundelkhand, Mysore and South Uttar Pradesh. In Darjeeling-Duars and Coorg the comparison is obscured because the ALE did not cover the plantations.

In a few divisions relatively low proportions of both landholders and labourers are associated with a high proportion of persons dependent on non-agriculture. This is the case in the rural areas of Saurashtra, Kutch, Punjab Plain, West Uttar Pradesh and Delhi. High percentages for non-agriculture are also typical of West Bengal Plain, Malabar, Travancore-Cochin, Tamilnad, Telengana and Coastal Andhra, where high agricultural labour percentages have already been noted. Low figures for non-agriculture were recorded in Mysore and Bundelkhand as well as in three divisions with high percentages of landholders : Assam Hills, Kumaon-Garhwal, Gwalior, and six divisions with high percentages of labourers : Berar-Nagpur, Marathwada, Deccan, North Karnatak, Dhar-Jhabua-Nimar and Chhattisgarh.

RCS data on cultivating families. The third All-India enquiry which we have used to check the Census of 1951 data is the Rural Credit Survey (RCS). We have taken from the RCS the percentages of cultivating families to all families in the sample villages, and from the Census the percentage of cultivating owners and tenants plus their dependents (Livelihood Classes I and II) to the whole rural population. The RCS counted as a cultivating family every household in possession of a plot of land larger than a mere garden patch. Since the RCS data is available only for 75 districts, we have calculated the Census proportions for these particular districts. Table A.12 in Appendix 2 shows the comparison, the districts being listed according to the States and divisions in which they are now included.

It must be noted that percentages calculated with the family as the unit are not precisely comparable with figures which take into account the number of persons in the families. The RCS percentages are of the former type; the Census percentages of the latter. Nonetheless, the differences arising from this particular incompatability should not be great. In most districts, the RCS found a somewhat higher proportion of cultivators than the Census. The overall extent of agreement is indicated by the product moment coefficient of correlation between the two series of 75 district percentage: .448. This is much less than the correlation between the Census and ALE figures for landholders and their dependents in 48 divisions.

Conformity with patterns indicated by Census and ALE. It is difficult to compare all three (Census, ALE, RCS) simultaneously since figures for individual districts cannot be equated with figures for the divisions in which the districts are included. For nine of the smaller divisions there is no RCS data at all. In all but half a dozen of the remaining divisions, however, we may observe evidence of a general tendency toward agreement. Thus the RCS figures tend to support the Census and ALE in the sense of identifying relatively high percentages (70 or over) of cultivators' families in Tripura, Chhota Nagpur, Konkan, Dhar-Jhabua-Nimar, Old Mysore State, Himachal, Jodhpur-Bikaner, Kotah-Bundi and five of the six sample districts in East and Central Uttar Pradesh. Again, we find relatively low percentages (59 or less) of cultivators according to all three sources in Coastal Andhra, Berar-Nagpur and Bhopal.

Shifting to the district level, we note that both Census and RCS give high percentages of cultivators for Kamrup (Assam Valley), Kolhapur (Deccan), Bilaspur (Chhattisgarh), and Sawaimadhopur (Jaipur). ALE percentages for the four divisions in which these districts are located are also high. In addition, Census and RCS indicate high proportions of cultivators in Shivpuri (Malwa Division), Hissar (Punjab Plain), Mohindergarh (Patiala), Shahjahanpur (West U.P.), and Midnapur (West Bengal Plain). The high RCS figure for cultivators in Jalpaiguri (Darjeeling-Duars) conforms closely to the ALE figure for the division; the low Census percentages for district and division result from the inclusion of plantation areas.

Low district percentages of cultivators were found by Census and RCS in Mahbubnagar (Telengana), Monghyr North (N. Bihar), Parbhani and Osmanabad (Marathwada), Ahmedabad and Broach (Gujarat), Bhilsa (Malwa), Coimbatore (Tamilnad), Jullunder (Punjab Plain) and Burdwan (West Bengal Plain). For these nine divisions the ALE also found relatively low proportions of cultivating families.

In an additional ten districts, the percentages calculated from Census and RCS data fall in the median range (60-69). These are Bhagalpur (South Bihar), West Khandesh (Deccan), Sorath (Saurashtra), Shajapur (Malwa), Rewa (Bundelkhand), Puri (Coastal Orissa), Sambalpur (Inland Orissa), Ballia (East U.P.), Hamirpur and Mirzapur (South U.P.).

There are a few RCS figures which appear totally out of line with both Census and ALE. The RCS classed 70 percent or more of the families as cultivating in three Andhra districts, both Kerala districts, one Tamilnad district, and Sagar district in Madhya Pradesh. We recognise these as areas in which the Census and ALE reported relatively low proportions of landholders and correspondingly high proportions of agricultural labourers or non-agriculturists or both. By contrast, the RCS reported a very low percentage of cultivators in Nainital district of Kumaon-Garhwal division, where Census and ALE found high percentages. These discrepancies may reflect the nature of the RCS sample.

Recapitulation of argument. Apart from these particular cases, we may say that the Census and the RCS show a substantial degree of convergence in the characterization of the 75 districts according to the prevalence of cultivating families among the rural population. We have already seen that there is considerable agreement between the Census and the ALE in respect of the *relative* proportions of landholding families, agricultural labour families, and non-agricultural families in the 48 divisions. We have also shown that the Census and the ALE tend to concur on the *ranking* of the 17 major 1951 States by the percentages of the working force employed in cultivation of own land, in agricultural labour, and in other work. We find approximately the same agreement between the two sources whether we calculated the percentages in terms of principal occupation alone or whether we also take secondary employment into consideration.

On the strength of these findings the 1951 Census percentages for three broad occupational bands—cultivators, agricultural labourers, and non-agriculturists—may be accepted as fairly reliable indications of regional differences. To this extent the 1951 occupational distribution constitutes a base against which the 1961 returns may fruitfully be viewed.

Our analysis of the two chief aspects of the Census of 1951 economic data has led to two sharply distinct evaluations. On the one hand, we have found cause for rejecting the apparent variation from State to State and division to division in size of working force. On the other, we have presented reasons for crediting the Census of 1951 returns as a guide to the variation from region to region in occupational pattern.

Appendix 1

CENSUS NATURAL DIVISIONS AND ALE ZONES

States as of 1960 natural divisions	districts included	census code	ALE zones
Andhra			
Coastal Andhra	Srikakulam, Vishakapatnam, East Godavari, West Godavari, Krishna, Guntur, Nellore	5.12	Madras I+VII
Telengana	Hyderabad, Mahbubnagar, Nizambad, Medak, Karimnagar, Khammam, Warangal, Nalgonda, Raichur,[2] Gulbarga,[2] Adilabad[1]	3.51	Hyderabad II
Rayalaseema	Bellary,[2] Anantapur, Cuddapah, Kurnool	3.54	Madras III
Assam			
Assam Valley	Cachar, Goalpara, Kamrup, Darrang, Nowgong, Sibsagar, Lakhimpur	1.21	Assam I+II
Assam Hills	Garo Hills, United Khasi Jaintia Hills, Mihir and North Cachar Hills, Mizo, Naga Hills, and North East Frontier Agency	1.22	Assam III
Manipur	Single unit	1.23	Manipur
Tripura	Single unit	1.24	Tripura
Bihar			
North Bihar	Saran, Champaran, Muzaffarpur, Darbhanga, Purnea,[1] Monghyr North, Saharsa	2.12	Bihar I+II
South Bihar	Patna, Gaya, Shahabad, Bhagalpur, Monghyr South	2.13	Bihar III
Chhota Nagpur	Hazaribagh, Ranchi, Dhanbad, Palamau, Singhbhum, Manbhum,[1] Santhal Parganas	3.31	Bihar IV
Gujarat			
Gujarat	Banaskantha, Sabarkantha, Mehsana, Ahmedabad, Kaira, Panch Mahals, Baroda, Broach, Surat, Amreli	4.11	Bombay I
Saurashtra	Halar, Central Saurashtra, Zalawad, Gohilwad, Sorath	4.12	Saurashtra
Kutch	Single unit	4.13	Kutch
Jammu-Kashmir	Jammu, Kathua, Mirpur, Udhampur, Doda, Rajouri, Baramulla, Anantanag, Muzaffarabad, Srinagar	1.14	Jammu and Kashmir I, II

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[1] Parts of this district have been severed and are now included in another State or States.

[2] This district is now included in another State : Mysore.

CENSUS NATURAL DIVISIONS AND ALE ZONES—(*continued*)

States as of 1960 natural divisions	districts included	census code	ALE zones
Kerala			
Travancore-Cochin	Trivandrum,[1] Quilon,[1] Kottayam, Trichur	4.24	Travancore-Cochin I, II
Malabar	Malabar, South Kanara,[2] Nilgiris[2]	4.23	Madras V+VI
Madhya Pradesh			
Gwalior	Bhind, Gwalior Gird, Morena	2.35	Madhya Bharat I
Malwa	(Shivpur),[3] Guna, Mandasaur, Rajgarh, Shajapur, Ujjain, Ratlam, Bhilsa, Indore, Dewas	3.13	Madhya Bharat II
Dhar-Jhabua-Nimar	(Dhar),[3] Jhabua, Nimar	3.14	Madhya Bharat III and IV
Bhopal	Sehore, Raisen	3.23	Bhopal
Jabalpur-Sagar	Mandla, Sagar, Jabalpur, Hoshangabad, Betul, Chhindwara, (Nimar)[3]	3.24	Madhya Pradesh II
Chhattisgarh	Balaghat, Bhandara,[2] Chanda,[2] Raipur, Bilaspur, Durg Bastar, Raigarh, Surguja	3.32	Madhya Pradesh III
Bundelkhand	Sidhi, Rewa, Satna, Shahdol, Datia, Chhatarpur, Tikamgarh, Panna	3.22	Vindhya Pradesh
Madras			
Tamilnad	Chittoor,[2] North Arcot, Salem, Coimbatore,[1] Tiruchirapalli, Madurai, Chingleput, Madras, South Arcot, Tanjore, Ramnad, Tirunelveli	5.21	Madras II+IV
Maharashtra			
Greater Bombay	Greater Bombay	4.21	
Konkan	Thana, Kolaba, Ratnagiri, Kanara[2]	4.22	Bombay V
Deccan	West Khandesh, East Khandesh, Dangs, Nasik, Ahmednagar, Poona, Satara North, Satara South, (Kolhapur),[3] Sholapur	3.43	Bombay II+III
Berar-Nagpur	Amraoti, Buldana, Akola, Yeotmal, Wardha, Nagpur	3.41	Madhya Pradesh I
Marathwada	Aurangabad, Parbhani, Nanded,[1] Bidar,[2] Bhir, Osmanabad	3.42	Hyderabad I
Mysore			
Mysore	Bangalore, Kolar, Tumkur, Mysore, Mandya, Chittaldrug, Hassan, Chickmaglur, Shimoga	3.53	Mysore I, II, III
Coorg	Single unit	4.25	Coorg
North Karnatak	Belgaum,[1] Bijapur, Dharwar	3.52	Bombay IV
Orissa			
Coastal	Balasore, Cuttack, Puri, Ganjam Plains	5.11	Orissa I
Inland	(Mayurbhanj),[3] (Keonjhar),[3] Dhenkanal, Sundergarh, Phulbani, Ganjam Agency, Sambalpur, Bolangir, Kalahandi, Koraput	3.33	Orissa II+III

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[1] Parts of this district have been severed and are now included in another State or States.

[2] This district is now included in another State: Bidar, Kanara and South Kanara in Mysore; Nilgiris in Madras; Bhandara and Chanda in Maharashtra; Chittoor in Andhra.

[3] Parentheses indicate that this district was classified in another zone in the Agricultural Labour Enquiry.

CENSUS NATURAL DIVISIONS AND ALE ZONES—*(concluded)*

States as of 1960 natural divisions	districts included	census code	ALE zones
Punjab			
Punjab Plain	Ambala, Gurdaspur, Hoshiarpur, Amritsar, Jullundhur, Ludhiana, Ferozepur, Karnal, Hissar, Rohtak, Gurgaon	2.31	Punjab
Patiala	Patiala, Barrala, Bhatinda, Mohindergarh, Kapurthala, Sangrur, Kohistan, Fategarh Sahib	2.32	PEPSU
Kangra	(Kangra)[1], (Simla)[1]	1.13	Included in Punjab
Delhi	Single unit	2.33	Delhi.
Himachal	Chamba, Mandi, Sirmoor, Mahasu, Bilaspur	1.12	Himachal, Bilaspur
Rajasthan			
Jaipur-Alwar	Jaipur, Tonk, Bharatpur, Sawaimadhopur, Alwar, Sikar, Bhilwara, Jhunjhunu	2.34	Rajasthan I
Ajmer	Single unit	2.36	Ajmer
Jodhpur-Bikaner	Bikaner, Churu, Jodhpur, Ganganagar, Jalore, Pali, Nagore, Jaisalmer	2.41	Rajasthan II, IV
Mewar	Udaipur, Dungarpur, Banswara, Sirohi	3.11	Rajasthan III
Kotah-Bundi	Chittorgarh, Kotah, Bundi, Jhalawar	3.12	Rajasthan V
Uttar Pradesh			
Kumaon-Garhwal	Garhwal, Tehri-Garhwal, Nainital, Almora, (Dehra Dun)[1]	1.11	U.P. IV
East U.P.	Gorakhpur, Basti, Gonda, Bahraich, Deoria, Banaras, Jaunpur, Ghazipur, Ballia, Azamgarh	2.14	U.P. I+V
Oudh	Kanpur, Fatehpur, (Allahabad)[1], Lucknow, Unao, Rai-Bareli, Sitapur, Hardoi, Faizabad, Sultanpur, Pratapgarh Bara Banki	2.21	U.P. II
West U.P.	Saharanpur, Bareilly, Bijnor, Rampur, Muzaffarnagar, Bulandshahr, (Pilibhit[1]), (Kheri)[1], Meerut, Aligarh, Mathura, Agra, Mainpuri, Etah, Budaun, Moradabad, Shahjahanpur, Etawah, Farrukhabad	2.22	U.P. III
South U.P.	Jhansi, Jhalaur, Banda, Hamirpur, Mirzapur	3.21	U.P. VI
West Bengal			
Darjeeling-Duars	Darjeeling, Jalpaiguri, Cooch Behar	1.25	W. Bengal I, II, VIII
West Bengal Plain	Hooghly, Howrah, 24-Parganas, Calcutta, Burdwan, Birbhum, Bankura, Midnapore, Nadia, Murshidabad, Malda, West-Dinajpur	2.11	W. Bengal III, IV, V, VI, VII
Chandernagore	Single unit	..	
Sikkim	Single unit	1.26	

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[1] Parentheses indicate that this district was classified in another zone in the Agricultural Labour Enquiry.

Appendix 2 : Tables

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	males			females			persons	
major States*	all males (000)	age-15–64 per 100 males	SSP's + ED's per 100 males	all females (000)	age-group 15–64 per 100 females	SSP's + ED's per 100 females	age-group 15–64 per 100 persons	SSP's + ED's per 100 persons
Assam	4,812	55.69	54.00	4,232	53.56	30.76	54.70	43.13
Bihar	20,224	56.32	49.90	20,002	56.70	21.26	56.46	35.66
Bombay	18,615	58.82	54.80	17,341	57.58	29.93	58.22	42.80
Hyderabad	9,431	57.82	59.61	9,224	57.35	31.42	57.59	45.67
Madhya Bharat	4,133	59.87	56.89	3,821	57.85	24.38	58.90	41.27
Madhya Pradesh	10,663	58.40	63.60	10,585	58.47	47.75	58.43	55.70
Madras	28,419	60.56	47.32	28,597	60.77	14.72	60.67	30.97
Mysore	4,657	59.36	47.74	4,418	56.52	10.05	57.98	29.39
Orissa	7,243	59.02	57.24	7,403	59.66	19.59	59.34	38.21
PEPSU	1,895	55.15	59.73	1,599	54.52	14.40	54.86	38.99
Punjab	6,648	54.83	56.50	5,742	53.42	19.56	54.18	39.38
Rajasthan	7,962	57.00	60.68	7,329	57.21	39.30	57.10	50.43
Saurashtra	2,094	55.68	53.46	2,043	56.17	29.72	55.92	41.74
Travancore-Cochin	4,621	57.15	49.74	4,660	58.02	22.67	57.59	36.15
Uttar Pradesh	33,099	58.79	59.00	30,117	57.68	24.27	58.27	42.46
Vindhya Pradesh	1,833	59.41	59.10	1,742	59.80	32.52	59.60	46.15
West Bengal	13,345	63.71	54.77	11,465	59.83	11.29	61.93	34.68

* As of 1951.

Sources : Census of India, 1951, Vol. 1, Part II-B *Economic Tables (General Population)* and Volume 1, Part II-A *Demographic Tables*. The age distribution is based on a 10% sample tabulation.

TABLE A.2. PERCENTAGE DISTRIBUTION OF GENERAL POPULATION BY HOUSEHOLD ECONOMIC STATUS ACCORDING TO CENSUS OF 1951

census jurisdiction		all males (000)	self supporting persons		earning dependents		non-earning dependents	
code	natural division		as % of all males	quartile*	as % of all males	quartile*	as % of all males	quartile*
		(a) males						
Assam, Manipur, Tripura								
1.21	Assam Valley	4,179	42.6	IV	11.4	I	46.0	II
1.22	Assam Hills	633	44.6	III	9.6	II	45.8	II
1.23	Manipur	284	39.5	IV	13.7	I	46.8	I
1.24	Tripura	336	45.5	III	9.8	II	44.6	II
Bihar								
2.12	North Bihar	9,001	45.7	III	4.2	IV	50.1	I
2.13	South Bihar	5,689	42.7	IV	4.2	IV	53.1	I
3.31	Chhota Nagpur	5,534	48.3	II	4.7	IV	47.1	I
Bombay, Saurashtra, Kutch								
3.43	Bombay Deccan	6,284	43.6	IV	9.7	II	46.7	II
3.52	North Karnatak	2,392	45.0	III	10.4	II	44.6	II
4.11	Gujarat	5,885	44.1	IV	9.0	II	46.9	I
4.21	Greater Bombay	1,779	65.3	I	2.3	IV	32.4	IV
4.22	Konkan	2,274	44.2	III	8.4	II	47.4	I
4.12	Saurashtra	2,094	42.1	IV	11.4	I	46.5	II
4.13	Kutch	273	47.3	III	8.0	III	44.7	II
Hyderabad								
3.42	Marathwada	3,016	41.5	IV	16.9	I	41.6	III
3.51	Telengana	6,415	46.2	III	14.0	I	39.8	IV
Madhya Bharat and Bhopal								
2.35	Gwalior	910	50.7	II	5.8	III	43.5	II
3.13	Malwa	2,385	49.8	II	7.3	III	42.9	III
3.14	Dhar-Jhabua-Nimar	839	49.3	II	7.3	III	43.4	III
3.23	Bhopal	438	51.6	I	4.9	IV	43.4	II
Madhya Pradesh								
3.24	Jabalpur-Sagar	2,784	50.6	II	11.5	I	37.9	IV
3.32	Chhattisgarh	5,056	50.7	II	14.7	I	34.6	IV
3.41	Berar-Nagpur	2,822	49.8	II	12.1	I	38.1	IV
Madras, Coorg								
3.54	Rayalaseema	2,572	41.8	IV	5.1	III	53.1	I
4.23	Malabar, S. Kanara	3,319	41.2	IV	3.3	IV	55.5	I
5.12	Andhra Coastal	7,212	44.2	III	6.6	III	49.2	I
5.21	Tamilnad	15,315	42.9	IV	3.5	IV	53.6	I
4.25	Coorg	125	52.0	I	3.2	IV	44.8	II
Mysore								
3.53	Mysore	4,657	43.7	IV	4.0	IV	52.3	I
Orissa								
3.33	Orissa Inland	3,972	48.2	III	9.8	II	42.0	III
5.11	Orissa Coastal	3,271	47.6	III	8.7	II	43.7	II

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* Notes given on p. 160.

TABLE A.2. PERCENTAGE DISTRIBUTION OF GENERAL POPULATION BY HOUSEHOLD ECONOMIC STATUS ACCORDING TO CENSUS OF 1951—(*continued*)

census jurisdiction code natural division		all males (000)	self-supporting persons		earning dependents		non-earning dependents	
			as % of all males	quartile*	as % of all males	quartile*	as % of all males	quartile*
Punjab, PEPSU, Delhi, Himachal, Bilaspur								
1.13	Kangra	509	47.0	III	14.3	I	38.7	IV
2.31	Punjab	6,139	45.5	III	10.6	I	43.9	II
2.32	Patiala	1,895	52.7	I	7.0	III	40.3	III
2.33	Delhi	987	53.6	I	5.3	III	41.1	III
1.12	Himachal	580	55.9	I	11.4	I	32.8	IV
Rajasthan, Ajmer								
2.34	Jaipur-Alwar	3,448	52.5	I	9.5	II	38.0	IV
2.41	Jodhpur-Bikaner	2,416	52.5	I	5.7	III	41.8	III
3.11	Mewar	1,062	49.5	II	10.7	I	39.7	IV
3.12	Kotah-Bundi	1,036	53.2	I	9.2	II	37.6	IV
2.36	Ajmer	360	52.8	I	8.1	III	39.2	IV
Travancore-Cochin								
4.24	Travancore-Cochin	4,621	43.9	IV	5.8	III	50.3	I
Uttar Pradesh								
1.11	Kumaon-Garhwal	1,284	50.8	II	7.7	III	41.5	III
2.14	East U.P.	9,037	50.0	II	8.3	II	41.7	III
2.21	Oudh	8,451	51.5	II	8.0	III	40.5	III
2.22	West U.P.	12,312	55.7	I	3.4	IV	40.9	III
3.21	South U.P.	2,015	51.3	II	8.6	II	40.1	III
Vindhya Pradesh								
3.22	Vindhya Pradesh	1,833	49.6	II	9.5	II	40.9	III
West Bengal and Sikkim								
1.25	Darjeeling	1,102	51.6	I	2.6	IV	45.8	II
2.11	Calcutta Industrial Area	2,857	62.7	I	1.3	IV	36.0	IV
2.11	W. Bengal excluding Calcutta	9,386	47.0	III	5.0	IV	48.0	I
1.26	Sikkim	72	41.7	IV	19.4	I	38.9	IV
			(b) females					
Assam, Manipur, Tripura								
1.21	Assam Valley	3,626	11.7	II	17.1	II	71.2	II
1.22	Assam Hills	605	21.2	I	21.6	II	57.2	IV
1.23	Manipur	294	15.3	II	35.7	I	49.0	IV
1.24	Tripura	303	16.2	I	13.5	III	70.3	III
Bihar								
2.12	North Bihar	9,117	15.8	I	2.5	IV	81.7	II
2.13	South Bihar	5,552	16.9	I	4.7	IV	78.4	II
3.31	Chhota Nagpur	5,333	20.9	I	5.1	IV	74.0	II

* Notes given on p. 160.

TABLE A.2. PERCENTAGE DISTRIBUTION OF GENERAL POPULATION BY HOUSEHOLD ECONOMIC STATUS ACCORDING TO CENSUS OF 1951—(*continued*)

census jurisdiction		all females (000)	self-supporting persons		earning dependents		non-earning dependents	
code	natural division		as % of all females	quartile*	as % of all females	quartile*	as % of all females	quartile*
				(b) females				
Bombay, Saurashtra, Kutch								
3.43	Bombay-Deccan	6,081	6.2	IV	24.6	II	69.2	III
3.52	North Karnatak	2,806	9.7	II	22.8	II	67.5	III
4.11	Gujarat	5,512	5.7	IV	23.7	II	70.6	II
4.21	Greater Bombay	1,060	9.4	III	1.8	IV	88.7	I
4.22	Konkan	2,382	8.6	III	26.3	I	65.1	III
4.12	Saurashtra	2,043	4.6	IV	25.1	II	70.3	III
4.13	Kutch	295	10.8	II	20.0	II	69.2	III
Hyderabad								
3.42	Marathwada	2,930	5.1	IV	27.6	I	67.3	III
3.51	Telengana	6,294	7.2	IV	23.7	II	69.1	III
Madhya Bharat and Bhopal								
2.35	Gwalior	782	6.3	IV	5.1	III	88.6	I
3.13	Malwa	2,231	10.1	II	13.4	IV	76.5	II
3.14	Dhar-Jhabua-Nimar	808	22.5	I	17.0	III	60.5	IV
3.23	Bhopal	399	18.0	I	6.8	III	75.2	II
Madhya Pradesh								
3.24	Jabalpur-Sagar	2,706	8.8	III	32.4	I	58.8	IV
3.32	Chhattisgarh	5,143	11.9	II	42.1	I	46.0	IV
3.41	Berar-Nagpur	2,735	7.8	III	34.8	I	57.4	IV
Madras Coorg								
3.54	Rayalaseema	2,465	11.5	II	5.8	III	82.7	I
4.23	Malabar, S. Kanara	3,500	11.8	II	3.5	IV	84.7	I
5.12	Andhra Coastal	7,221	8.4	III	8.3	III	83.3	I
5.21	Tamilnad	15,410	9.5	III	3.7	IV	86.7	I
4.25	Coorg	104	16.3	I	5.8	III	77.9	II
Mysore								
3.53	Mysore	4,418	7.3	III	2.7	IV	90.0	I
Orissa								
3.33	Orissa Inland	4,001	9.5	III	14.4	III	76.1	II
5.11	Orissa Coastal	3,402	9.7	III	4.8	IV	85.5	I
Punjab, PEPSU, Delhi, Himachal, Bilaspur								
1.13	Kangra	464	11.4	II	32.3	I	56.3	IV
2.31	Punjab	5,278	4.3	IV	13.1	III	82.6	II
2.32	Patiala	1,599	2.9	IV	11.5	III	85.6	I
2.33	Delhi	758	4.2	IV	3.4	IV	92.3	I
1.12	Himachal	530	13.0	II	38.[illegible]	I	48.9	IV

* Notes given on p. 160.

TABLE A.2. PERCENTAGE DISTRIBUTION OF GENERAL POPULATION BY HOUSEHOLD ECONOMIC STATUS ACCORDING TO CENSUS OF 1951—(*concluded*)

census jurisdiction		all females (000)	self-supporting persons		earning dependents		non-earning dependents	
code	natural division		as % of all females	quartile*	as % of all females	quartile*	as % of all females	quartile*
				(b) females				
Rajasthan, Ajmer								
2.34	Jaipur-Alwar	3,137	22.2	I	18.6	II	59.2	IV
2.41	Jodhpur-Bikaner	2,188	22.6	I	11.0	III	66.4	III
3.11	Mewar	1,032	15.8	II	28.6	I	55.6	IV
3.12	Kotah-Bundi	972	16.2	I	25.9	II	57.9	IV
2.36	Ajmer	333	19.2	I	17.4	II	63.4	III
Travancore-Cochin								
4.24	Travancore-Cochin	4,660	13.3	II	9.4	III	77.3	II
Uttar Pradesh								
1.11	Kumaon-Garhwal	1,238	6.9	IV	43.8	I	49.3	IV
2.14	East U.P.	8,850	8.0	III	27.3	I	64.7	III
2.21	Oudh	7,679	7.1	IV	20.7	II	72.2	II
2.22	West U.P.	10,459	3.5	IV	3.2	IV	93.3	I
3.21	South U.P.	1,891	8.2	III	30.1	I	61.7	III
Vindhya Pradesh								
3.22	Vindhya Pradesh	1,742	12.5	II	20.0	II	67.5	III
West Bengal and Sikkim								
1.25	Darjeeling	929	16.5	I	2.0	IV	81.5	II
2.11	Calcutta Industrial Area	1,720	8.6	III	0.5	IV	90.9	I
2.11	West Bengal excluding Calcutta	8,816	8.4	III	2.6	IV	89.0	I
1.26	Sikkim	66	6.0	IV	47.0	I	47.0	IV

Source : Census of India, 1951, Vol. I, Part II-B.

*The percentages of the total male (or female) population returned in each of the 52 natural divisions have been separately arranged in order of rank for each of the three status categories, and then grouped into four quartiles. Roughly we may say : I. very high percentage ; II. fairly high ; III. fairly low, and IV. very low.

Thus, for example, we see that as compared with other areas, the percentages of self-supporting males returned in Assam, Manipur and Tripura were low, while the percentages of earning dependents were high. By contrast, in Madhya Bharat and Bhopal, the percentages returned as self-supporting were high, and those of earning dependents low. In Madhya Pradesh both sets of earning percentages were high, in Madras both sets were low.

TABLE A.3. DISTRIBUTION OF GENERAL POPULATION BY ECONOMIC STATUS IN SELECTED STATES : CENSUSES OF 1931, 1941 AND 1951

States categories	1931 1941 1951	earners independent persons self-supporting persons	working dependents partly dependents earning dependents	dependents total dependents non-earning dependents	all males
		(a) males (000)			
Bihar and Orissa	1931	11,938	305	8,839	21,082
	1941	12,212	1,398	10,417	24,028
	1951	12,682	1,556	13,229	27,467
Bombay*	1931	7,127	609	5,133	12,869
	1941	6,044	967	5,579	12,589
	1951	8,576	1,625	8,413	18,614
Madras	1931	12,884	935	9,482	23,301
	1941	11,741	1,063	11,997	24,800
	1951	12,192	1,257	14,970	28,419
Uttar Pradesh	1931	16,404	571	9,088	26,063
	1941	14,573	1,196	13,551	29,320
	1951	17,411	2,119	13,569	33,099

Percentage Distribution of General Population by Economic Status in Selected States : Censuses of 1931, 1941 and 1951

States		earners	working dependents	dependents	all males
Bihar and Orissa	1931	56.63	1.45	41.92	100.00
	1941	50.82	5.82	43.35	100.00
	1951	46.17	5.67	48.16	100.00
Bombay	1931	49.79	4.73	45.48	100.00
	1941	48.01	7.68	44.31	100.00
	1951	46.07	8.73	45.20	100.00
Madras	1931	55.29	4.02	40.69	100.00
	1941	47.34	4.29	48.37	100.00
	1951	42.90	4.42	52.68	100.00
Uttar Pradesh	1931	62.94	2.19	34.87	100.00
	1941	49.70	4.08	46.22	100.00
	1951	52.60	6.40	41.00	100.00

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*The figures for Bombay in 1931 cover the areas which were included in Bombay in 1951 except for a few minor princel. States transferred to Bombay from Rajputana and Western India Agency. The 1941 Bombay figures exclude as well the Deccan and Gujarat States since *Y*-sample slips were not available for these States.

Source : Census of 1931, India, Vol. I, Part II, Tables, pp. 2, 3, 218, 222, 386, 394 ; Madras 1931, Vol. XIV, Part II, pp. 2, 3, 106, 114.

Census of 1941, *Age Tables and Means of Livelihood and Industries Tables*—1941 Census on *Y*-sample, for Bihar, Orissa, Bombay, Madras and Uttar Pradesh. Census of 1951, Vol. I, Part II-B, pp. 2-3, 4-5, 14-15.

TABLE A.3. DISTRIBUTION OF GENERAL POPULATION BY ECONOMIC STATUS IN SELECTED STATES : CENSUSES OF 1931, 1941 AND 1951—(*continued*)

categories	1931	earners	working dependents	dependents	all females
	1941	independent persons	partly dependents	total dependents	
States	1951	self-supporting persons	earning dependents	non-earning dependents	
		(b) females (000)			
Bihar and Orissa	1931	4,978	394	15,875	21,247
	1941	3,029	2,478	18,758	24,265
	1951	4,207	1,495	21,703	27,405
Bombay*	1931	1,900	1,109	9,026	12,035
	1941	1,340	1,333	9,023	11,697
	1951	1,216	3,974	12,151	17,341
Madras	1931	5,205	7,171**	11,516	23,892
	1941	3,291	1,814	19,934	25,040
	1951	2,771	1,439	24,387	28,597
Uttar Pradesh	1931	4,314	2,871	16,367	23,552
	1941	2,085	1,269	23,222	26,575
	1951	1,848	5,461	22,808	30,117

Percentage Distribution of General Population by Economic Status in Selected States : Censuses of 1931, 1941 and 1951

States	year				
Bihar and Orissa	1931	23.43	1.85	74.72	100.00
	1941	12.48	10.21	77.30	100.00
	1951	15.35	5.46	79.19	100.00
Bombay	1931	15.78	9.22	75.00	100.00
	1941	11.46	11.40	77.14	100.00
	1951	7.01	22.92	70.07	100.00
Madras	1931	21.79	30.01**	48.20	100.00
	1941	13.15	7.24	79.61	100.00
	1951	9.69	5.03	85.28	100.00
Uttar Pradesh	1931	18.32	12.19	69.49	100.00
	1941	7.85	4.77	87.38	100.00
	1951	6.14	18.13	75.73	100.00

*See note for *Males Only*.

**This figure includes 6,086,000 females returned as working dependents in domestic service.

TABLE A.3. DISTRIBUTION OF GENERAL POPULATION BY ECONOMIC STATUS IN SELECTED STATES: CENSUSES OF 1931, 1941 AND 1951—*(concluded)*

categories	1931	earners	working dependents	dependents	
States	1941	independent persons	partly dependents	total dependents	all persons
	1951	self-supporting persons	earning dependents	non-earning dependents	
		(c) persons (000)			
Bihar and Orissa	1931	16,917	699	24,714	42,330
	1941	15,242	3,876	29,174	48,292
	1951	16,889	3,051	34,932	54,872
Bombay*	1931	9,027	1,718	14,159	24,904
	1941	7,384	2,300	14,602	24,286
	1951	9,792	5,599	20,565	35,956
Madras	1931	18,090	8,106**	20,998	47,194
	1941	15,033	2,877	31,931	49,841
	1951	14,963	2,696	39,357	57,016
Uttar Pradesh	1931	20,718	3,441	25,456	49,615
	1941	16,658	2,465	36,772	55,895
	1951	19,260	7,580	36,376	63,216

Percentage Distribution of General Population by Economic Status in Selected States: Censuses of 1931, 1941 and 1951

States	Year				
Bihar and Orissa	1931	39.96	1.65	58.39	100.00
	1941	31.56	8.03	60.41	100.00
	1951	30.78	5.56	63.66	100.00
Bombay	1931	33.36	6.90	59.74	100.00
	1941	30.40	9.47	60.13	100.00
	1951	27.23	15.57	57.20	100.00
Madras	1931	38.33	17.18**	44.49	100.00
	1941	30.16	5.77	64.07	100.00
	1951	26.24	4.73	69.03	100.00
Uttar Pradesh	1931	41.76	6.94	51.30	100.00
	1941	29.80	4.41	65.79	100.00
	1951	30.47	11.99	57.54	100.00

* See note for *Males Only*.

** This figure includes 6,086,000 females returned as working dependents in domestic service.

TABLE A.4. PERCENTAGE DISTRIBUTION OF RURAL POPULATION BY ECONOMIC STATUS ACCORDING TO CENSUS OF 1951 AND AGRICULTURAL LABOUR ENQUIRY*

States and divisions	source census ALE	all males	SSP earner	ED helper	NED dependent
		(a) males only			
Andhra					
Coastal Andhra	census	6,932,621	43.9	6.9	49.2
	ALE	8,245	53.2	11.5	35.3
Telengana	census	5,080,105	45.5	16.0	38.5
	ALE	6,500	54.3	13.9	31.8
Rayalaseema	census	2,149,413	41.6	5.1	53.2
	ALE	3,720	47.7	16.3	36.0
Assam					
Valley	census	3,976,213	42.2	11.8	46.0
	ALE	4,226	37.1	21.6	41.3
Hills	census	589,717	43.8	10.2	46.0
	ALE	1,447	35.4	30.1	34.5
Manipur	census	283,685	39.6	13.5	46.9
	ALE	1,326	41.8	13.8	44.4
Tripura	census	312,385	45.4	10.3	44.3
	ALE	1,350	40.3	21.3	38.4
Bihar					
North Bihar	census	8,661,341	45.8	4.2	50.0
	ALE	13,917	46.0	17.5	36.5
South Bihar	census	5,029,349	42.9	4.2	52.9
	ALE	5,770	43.5	19.7	36.8
Chhota Nagpur	census	5,070,947	48.2	4.9	46.9
	ALE	7,818	48.8	15.1	36.1
Gujarat					
Gujarat	census	4,330,883	42.8	10.2	47.0
	ALE	8,991	39.6	17.4	43.0
Saurashtra	census	1,397,621	42.3	13.2	44.5
	ALE	3,636	39.9	21.4	38.7
Kutch	census	217,687	47.0	8.9	44.1
	ALE	2,100	41.8	15.8	42.9
Jammu & Kashmir	census		not taken		
	ALE	5,021	32.9	34.6	32.5
Kerala					
Travancore-Cochin	census	3,869,657	43.5	5.9	50.6
	ALE	16,362	47.9	5.8	46.3
Malabar	census	2,901,133	40.5	3.4	56.1
	ALE	7,977	47.5	10.2	42.3

* See note on p. 169.

TABLE A.4. PERCENTAGE DISTRIBUTION OF RURAL POPULATION BY ECONOMIC STATUS ACCORDING TO CENSUS OF 1951 AND AGRICULTURAL LABOUR ENQUIRY*—(*continued*)

States and divisions	source census ALE	all males	SSP earner	ED helper	NED dependent
Madhya Pradesh					
Gwalior	census	744,712	50.5	6.4	43.1
	ALE	2,795	33.6	29.4	37.0
Malwa	census	1,866,770	49.8	8.2	42.0
	ALE	1,733	46.2	14.5	39.3
Dhar-Jhabua-Nimar	census	764,866	49.3	7.5	43.2
	ALE	2,155	42.2	22.9	34.9
Bhopal	census	365,702	51.5	5.5	43.0
	ALE	960	51.7	16.3	32.1
Jabalpur-Sagar	census	2,338,361	50.8	12.7	36.5
	ALE	2,801	48.1	12.3	39.6
Chhattisgarh	census	4,757,793	50.6	15.2	34.2
	ALE	5,603	46.4	18.4	35.2
Bundelkhand	census	1,673,635	49.5	9.8	40.7
	ALE	3,393	41.6	21.1	37.3
Madras					
Tamilnad	census	11,712,378	42.5	3.2	54.3
	ALE	16,807	54.5	10.4	35.1
Maharashtra					
Greater Bombay	census		no rural population		
	ALE				
Konkan	census	1,802,483	43.6	9.2	47.2
	ALE	2,734	42.2	17.7	40.1
Deccan	census	4,574,690	42.5	11.2	46.3
	ALE	4,833	39.7	19.8	40.4
Berar-Nagpur	census	2,071,696	50.8	13.8	35.4
	ALE	3,432	55.6	10.1	34.2
Marathwada	census	2,586,751	41.1	18.4	40.5
	ALE	6,372	48.2	14.8	37.0
Mysore					
Mysore State	census	3,520,509	43.7	3.5	52.8
	ALE	5,082	45.0	19.6	35.4
Coorg	census	116,040	51.1	3.6	45.3
	ALE	1,198	48.6	9.3	42.1
North Karnatak	census	1,761,688	45.0	11.4	43.6
	ALE	3,817	39.6	20.7	39.7
Orissa					
Coastal	census	3,074,157	47.3	7.0	43.7
	ALE	4,146	48.9	14.4	36.7
Inland	census	3,852,859	48.2	9.9	41.9
	ALE	3,784	47.2	15.3	37.5

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* See note on p. 169.

TABLE A.4. PERCENTAGE DISTRIBUTION OF RURAL POPULATION BY ECONOMIC STATUS ACCORDING TO CENSUS OF 1951 AND AGRICULTURAL LABOUR ENQUIRY*—*(continued)*

Sstates and divisions	source census ALE	all males	SSP earner	ED helper	NED dependent
Punjab					
Punjab Plain	census	4,895,364	45.6	11.3	43.1
	ALE	15,614	39.4	22.7	37.9
Patiala	census	1,529,539	53.2	7.7	39.1
	ALE	6,807	38.0	20.0	42.0
Punjab Hills	census	454,687	44.9	15.8	39.3
	ALE		separate	figure not	available
Delhi	census	167,106	49.2	8.6	42.2
	ALE	4,902	40.2	14.8	45.0
Himachal	census	553,903	56.0	11.6	32.4
	ALE	2,387	42.5	17.6	39.9
Rajasthan					
Jaipur-Alwar	census	2,806,178	53.9	10.5	35.6
	ALE	3,392	39.4	24.1	36.5
Ajmer	census	202,869	54.1	12.2	33.7
	ALE	2,849	42.4	27.6	30.0
Jodhpur-Bikaner	census	1,943,414	53.9	6.2	39.9
	ALE	2,453	37.0	23.8	39.2
Mewar	census	950,378	49.4	11.6	39.0
	ALE	1,739	41.2	20.6	38.2
Kotah-Bundi	census	890,443	53.2	10.1	36.7
	ALE	597	42.1	18.4	39.5
Uttar Pradesh					
Kumaon-Garhwal	census	1,105,287	49.6	8.6	41.8
	ALE	946	42.1	19.1	38.8
East U. P.	census	8,341,307	50.0	8.6	41.4
	ALE	11,250	41.7	21.4	36.9
Oudh	census	7,183,669	51.1	8.8	40.1
	ALE	9,974	44.5	24.1	31.4
West U.P.	census	10,005,692	56.8	3.3	39.9
	ALE	14,614	40.9	21.8	37.3
South U.P.	census	1,724,194	51.2	9.3	39.5
	ALE	2,886	45.5	16.2	38.3
West Bengal					
Darjeeling-Duars	census	978,384	51.3	2.7	46.0
	ALE	3,974	46.0	22.6	31.4
W. Bengal Plain	census	8,653,029	46.8	5.2	48.0
	ALE	15,622	46.8	13.1	40.1
(Chandernagore)	census		no rural population		
	ALE				
Sikkim	census	70,582	41.0	20.6	38.4
	ALE		no villages surveyed		

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* See note on p. 169.

TABLE A.4. PERCENTAGE DISTRIBUTION OF RURAL POPULATION BY ECONOMIC STATUS ACCORDING TO CENSUS OF 1951 AND AGRICULTURAL LABOUR ENQUIRY*—(*continued*)

(b) females only

States and divisions	source census ALE	all females	SSP earner	ED helper	NED dependent
Andhra					
Coastal Andhra	census	6,038,150	8.7	9.2	82.1
	ALE	7,922	28.2	14.0	57.8
Telengana	census	4,991,606	6.8	27.6	65.6
	ALE	6,055	29.7	18.1	52.2
Rayalaseema	census	2,062,884	12.1	6.2	81.7
	ALE	3,588	29.8	26.1	44.1
Assam					
Valley	census	3,491,726	12.0	17.6	70.4
	ALE	3,764	7.3	30.3	62.4
Hills	census	571,633	21.8	22.6	55.6
	ALE	1,363	12.6	46.2	41.2
Manipur	census	293,950	15.2	35.8	49.0
	ALE	1,350	33.0	18.4	48.6
Tripura	census	284,049	16.7	14.4	68.9
	ALE	1,244	1.0	16.2	82.8
Bihar					
North Bihar	census	8,835,116	15.9	2.5	81.6
	ALE	13,170	13.9	24.7	61.4
South Bihar	census	4,976,620	17.8	4.7	77.5
	ALE	5,308	16.5	17.3	66.2
Chhota Nagpur	census	4,956,584	21.4	5.3	73.3
	ALE	7,216	23.8	15.4	60.8
Gujarat					
Gujarat	census	4,146,644	5.4	29.6	65.0
	ALE	8,666	9.7	31.8	58.5
Saurashtra	census	1,346,577	4.2	34.6	61.2
	ALE	3,512	13.6	32.2	54.2
Kutch	census	236,165	10.8	23.0	66.2
	ALE	2,300	16.4	21.7	61.9
Jammu & Kashmir	census			not taken	
	ALE	4,198	0.8	43.9	55.3
Kerala					
Travancore-Cochin	census	3,922,476	13.6	10.1	76.3
	ALE	16,688	27.7	6.1	66.2
Malabar	census	3,078,772	12.1	3.6	84.3
	ALE	8,131	21.2	16.0	62.8

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* See note on p. 169.

TABLE A.4. PERCENTAGE DISTRIBUTION OF RURAL POPULATION BY ECONOMIC STATUS ACCORDING TO CENSUS OF 1951 AND AGRICULTURAL LABOUR ENQUIRY*—(*continued*)

States and divisions	source census ALE	all females	SSP earner	ED helper	NED dependent
Madhya Pradesh					
Gwalior	census	636,615	6.7	5.8	87.5
	ALE	2,166	4.1	13.9	82.0
Malwa	census	1,762,335	11.1	16.0	72.9
	ALE	1,653	15.9	26.9	57.2
Dhar-Jhabua-Nimar	census	737,625	23.6	18.0	58.4
	ALE	2,057	11.8	41.3	46.9
Bhopal	census	334,709	20.2	7.8	72.2
	ALE	869	29.1	29.1	41.8
Jabalpur-Sagar	census	2,309,556	8.9	36.9	54.2
	ALE	2,738	20.9	33.2	45.9
Chhattisgarh	census	4,858,723	11.9	43.8	44.3
	ALE	5,762	20.1	37.1	42.8
Bundelkhand	census	1,595,145	12.5	21.2	66.3
	ALE	3,342	8.5	36.0	55.5
Madras					
Tamilnad	census	11,856,917	10.0	4.1	85.9
	ALE	17,595	33.7	19.3	47.0
Maharashtra					
Greater Bombay	census		no rural population		
	ALE				
Konkan	census	1,951,866	9.0	30.4	60.6
	ALE	3,010	14.5	41.6	43.9
Deccan	census	4,512,692	6.0	29.9	64.1
	ALE	4,910	14.1	36.9	49.0
Berar-Nagpur	census	2,034,065	8.2	42.8	49.0
	ALE	3,397	38.0	21.1	40.9
Marathwada	census	2,520,487	4.9	30.7	64.4
	ALE	6,264	23.0	21.1	55.9
Mysore					
Mysore State	census	3,375,736	7.8	2.9	89.3
	ALE	4,811	20.7	25.0	54.3
Coorg	census	97,110	16.1	6.3	77.6
	ALE	1,186	12.7	25.7	61.6
North Karnatak	census	1,704,864	9.9	27.0	63.1
	ALE	3,816	13.1	35.3	51.6
Orissa					
Coastal	census	3,230,761	9.7	4.9	85.4
	ALE	4,066	11.8	11.6	76.6
Inland	census	3,894,099	9.5	14.6	75.9
	ALE	3,683	13.9	12.2	73.9

* See note on p. 169.

TABLE A.4. PERCENTAGE DISTRIBUTION OF RURAL POPULATION BY ECONOMIC STATUS ACCORDING TO CENSUS OF 1951 AND AGRICULTURAL LABOUR ENQUIRY*—(*concluded*)

States and divisions	source census ALE	all females	SSP earner	ED helper	NED dependent
Punjab					
Punjab Plain	census	4,255,050	4.6	15.6	79.8
	ALE	13,107	4.6	7.5	87.9
Patiala	census	1,298,636	3.0	13.6	83.4
	ALE	5,560	2.0	2.4	95.6
Punjab Hills	census	429,926	10.8	34.7	54.5
	ALE		figures not available		
Delhi	census	139,832	4.7	12.8	82.5
	ALE	4,419	4.1	33.9	62.0
Himachal	census	510,417	13.2	39.1	47.1
	ALE	2,084	7.8	40.5	51.7
Rajasthan					
Jaipur-Alwar	census	2,539,894	24.9	21.0	54.1
	ALE	2,970	7.3	25.4	67.3
Ajmer	census	192,739	26.6	26.9	46.5
	ALE	2,613	9.1	49.1	41.8
Jodhpur-Bikaner	census	1,748,428	26.0	12.5	61.5
	ALE	2,166	4.2	25.0	70.8
Mewar	census	925,752	16.6	30.9	52.5
	ALE	1,692	2.1	44.0	53.9
Kotah Bundi	census	836,943	17.3	29.0	53.7
	ALE	557	8.8	42.2	49.0
Uttar Pradesh					
Kumaon-Garhwal	census	1,122,471	7.1	48.2	44.7
	ALE	885	3.1	47.3	49.6
East U. P.	census	8,253,164	8.0	28.9	63.1
	ALE	9,802	3.5	17.7	78.8
Oudh	census	6,694,802	7.4	23.4	69.2
	ALE	7,747	4.6	26.7	68.7
West U. P.	census	8,527,289	3.4	3.6	93.0
	ALE	12,145	2.1	10.5	87.4
South U.P.	census	1,632,168	8.2	33.8	58.0
	ALE	2,704	3.9	26.3	69.8
West Bengal					
Darjeeling-Duars	census	841,766	17.4	2.0	80.6
	ALE	3,599	13.2	23.9	62.9
W. Bengal Plain	census	8,183,866	8.3	2.7	89.0
	ALE	14,500	6.1	2.9	91.0
(Chandernagore)	census		no rural population		
	ALE				
Sikkim	census	64,399	4.9	48.9	46.2
	ALE		no villages surveyed		

Source: Census—Census of India 1951, Part II-C, *Economic Tables*, pp. 2, 4, 14. Agricultural Labour Enquiry—Government of India, Ministry of Labour, *Rural Manpower and Occupation Structure* 1954, Table No. 2 for all States.

TABLE A.5. PERCENTAGE DISTRIBUTION OF RURAL POPULATION BY "ECONOMIC STATUS" : CENSUS OF 1951, NATIONAL SAMPLE SURVEY (9th Round 1955) AND AGRICULTURAL LABOUR ENQUIRY (1951) FOR PART A STATES BEFORE 1956 REORGANIZATION

States	source	SSP's earners	ED's helpers	NED's dependents	not recorded	total	all males number of sample persons
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			(a) males				
	census	43.31	6.40	50.29	—	100.00	8,182,034
Andhra*	NSS	51.54	15.88	32.11	0.47	100.00	998
	ALE	51.50	12.95	35.55	—	100.00	11,965
	census	42.38	11.62	46.00	—	100.00	4,565,930
Assam	NSS	49.89	10.92	38.88	0.31	100.00	642
	ALE	36.68	23.75	39.57	—	100.00	5,673
	census	45.66	4.40	49.94	—	100.00	18,761,637
Bihar	NSS	46.25	9.56	43.98	0.21	100.00	2,396
	ALE	46.29	17.29	36.42	—	100.00	27,505
	census	43.14	10.60	46.26	—	100.00	12,469,744
Bombay	NSS	47.99	10.17	40.92	0.92	100.00	1,573
	ALE	39.96	18.64	41.40	—	100.00	20,375
	census	50.70	14.24	35.06	—	100.00	9,167,850
Madhya Pradesh	NSS	54.67	7.85	37.10	0.38	100.00	1,068
	ALE	49.48	14.57	35.95	—	100.00	11,836
	census	42.07	3.29	54.64	—	100.00	14,613,511
Madras*	NSS	48.16	13.60	37.12	1.12	100.00	1,561
	ALE	52.27	10.34	37.39	—	100.00	24,784
	census	47.76	9.48	42.76	—	100.00	6,927,016
Orissa	NSS	53.29	8.74	37.97	0.00	100.00	842
	ALE	48.08	14.81	37.11	—	100.00	7,930
	census	45.55	11.67	42.78	—	100.00	5,350,051
Punjab	NSS	52.33	4.26	43.22	0.19	100.00	785
	ALE	39.45	22.66	37.89	—	100.00	15,614
	census	52.75	6.82	40.43	—	100.00	28,360,149
Uttar Pradesh	NSS	50.59	7.68	41.44	0.29	100.00	3,665
	ALE	42.40	21.76	35.84	—	100.00	39,670
	census	47.24	4.94	47.82	—	100.00	9,631,413
West Bengal	NSS	48.85	9.98	40.56	0.61	100.00	1,167
	ALE	46.64	15.04	38.32	—	100.00	19,596
			(b) females				
	census	9.54	8.44	82.02	—	100.00	8,101,034
Andhra*	NSS	9.68	30.64	59.23	0.45	100.00	944
	ALE	28.68	17.76	53.55	—	100.00	11,510

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* See notes on p. 172.

TABLE A.5. PERCENTAGE DISTRIBUTION OF RURAL POPULATION BY "ECONOMIC STATUS": CENSUS OF 1951, NATIONAL SAMPLE SURVEY (9th Round 1955) AND AGRICULTURAL LABOUR ENQUIRY (1951) FOR PART A STATES BEFORE 1956 REORGANIZATION—(*continued*)

all females

States	source	SSP's earners	ED's helpers	NED's dependents	not recorded	total	number of sample persons
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Assam	census	13.36	18.32	68.32	—	100.00	4,063,359
	NSS	11.51	19.95	68.54	0.00	100.00	570
	ALE	8.72	34.50	56.78	—	100.00	5,127
Bihar	census	17.86	3.82	78.32	—	100.00	18,768,320
	NSS	5.27	16.76	77.88	0.09	100.00	2,433
	ALE	17.20	20.59	62.21	—	100.00	25,694
Bombay	census	6.80	29.47	63.73	—	100.00	12,316,066
	NSS	11.21	32.06	56.04	0.69	100.00	1,524
	ALE	12.10	35.11	52.79	—	100.00	20,402
Madhya Pradesh	census	10.31	41.83	47.86	—	100.00	9,202,344
	NSS	15.31	36.60	47.88	0.21	100.00	1,069
	ALE	25.40	31.61	42.99	—	100.00	11,897
Madras*	census	10.46	3.97	85.57	—	100.00	14,935,689
	NSS	14.72	24.67	59.79	0.82	100.00	1,600
	ALE	29.71	18.27	52.02	—	100.00	25,726
Orissa	census	9.60	10.18	80.22	—	100.00	7,124,860
	NSS	14.12	24.62	61.21	0.05	100.00	819
	ALE	12.81	11.89	75.30	—	100.00	7,749
Punjab	census	5.21	17.32	77.47	—	100.00	4,684,976
	NSS	2.92	6.36	90.27	0.45	100.00	703
	ALE	4.59	7.45	87.96	—	100.00	13,107
Uttar Pradesh	census	6.33	20.42	73.25	—	100.00	26,229,894
	NSS	9.85	12.56	77.40	0.19	100.00	3,461
	ALE	3.29	18.65	78.06	—	100.00	33,283
West Bengal	census	9.17	2.63	88.20	—	100.00	9,025,632
	NSS	8.18	8.37	83.28	0.17	100.00	1,188
	ALE	7.48	7.09	85.43	—	100.00	18,099
			(c) persons				
Andhra*	census	26.50	7.42	66.08	—	100.00	16,283,068
	NSS	31.28	23.02	45.24	0.46	100.00	1,942
	ALE	40.32	15.31	44.37	—	100.00	23,475
Assam	census	28.72	14.77	56.51	—	100.00	8,629,289
	NSS	31.26	15.31	53.27	0.16	100.00	1,212
	ALE	23.41	28.85	47.74	—	100.00	10,800
Bihar	census	31.75	4.11	64.14	—	100.00	37,529,957
	NSS	25.46	13.21	61.19	0.14	100.00	4,829
	ALE	32.24	18.89	48.87	—	100.00	53,199

* See notes on p. 172.

TABLE A.5. PERCENTAGE DISTRIBUTION OF RURAL POPULATION BY "ECONOMIC STATUS" : CENSUS OF 1951, NATIONAL SAMPLE SURVEY (9th Round 1955) AND AGRICULTURAL LABOUR ENQUIRY (1951) FOR PART A STATES BEFORE 1956 REORGANIZATION—(*concluded*)

States	source	SSP's earners	ED's helpers	NED's dependents	not recorded	total	all persons number of sample persons
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bombay	census	25.08	19.98	54.94	—	100.00	24,785,810
	NSS	30.15	20.79	48.26	0.80	100.00	3,097
	ALE	26.02	26.88	47.10	—	100.00	40,777
Madhya Pradesh	census	30.46	28.06	41.48	—	100.00	18,370,194
	NSS	34.99	22.22	42.49	0.30	100.00	2,137
	ALE	37.41	23.11	39.48	—	100.00	23,733
Madras	census	26.09	3.63	70.27	—	100.00	29,549,200
	NSS	31.28	19.18	48.57	0.97	100.00	3,161
	ALE	40.78	14.38	44.84	—	100.00	50,510
Orissa	census	28.41	9.84	61.75	—	100.00	14,051,876
	NSS	34.22	16.47	49.29	0.30	100.00	2,137
	ALE	30.65	13.36	55.99	—	100.00	15,679
Punjab	census	26.71	14.31	58.98	—	100.00	10,035,027
	NSS	29.20	5.25	65.24	0.3	100.00	1,488
	ALE	23.54	15.72	60.74	—	100.00	28,721
Uttar Pradesh	census	30.45	13.85	56.20	—	100.00	54,590,043
	NSS	30.91	10.04	58.81	0.24	100.00	7,126
	ALE	24.55	20.35	55.10	—	100.00	72,953
West Bengal	census	28.82	3.82	67.36	—	100.00	18,657,045
	NSS	28.18	9.15	62.28	0.39	100.00	2,355
	ALE	27.84	11.23	60.93	—	100.00	37,695

Source : Census ;—Census of India, 1951, Vol. I, Part II-C, *Economic Tables* (*Rural and Urban Population*) pp. 2-5, 14-15.

National Sample Survey : No. 16 *Employment and Unemployment* (May-November 1955), Delhi, 1959, Table 2(2), p. 125,

ALE ;—Government of India, Ministry of Labour, Agricultural Labour Enquiry, *Rural Manpower and Occupational Structure*—1954 Table No. 2 for all States.

General Note : "Economic Status" (or "Household Economic Status") is used in the Census of 1951 to denote the return of each individual as (a) a self-supporting person (SSP) ; (b) an earning dependent (ED) ; (c) a non-earning dependent (NED).

The National Sample Survey used three very similar categories : (a) earning ; (b) earning dependents; (c) non-earning dependents.

The Agricultural Labour Enquiry used three somewhat differently defined categories : (a) earners ; (b) helpers ; (c) dependents.

*Andhra *Madras :—The figures taken from the Census for Andhra refer to the "North Madras" and "Madras Deccan" divisions of the former Madras State. The latter division includes the entire Bellary district. Chittoor, although a part of Andhra, has been included in the figures for Madras since it was treated in the Census as part of the "South Madras" Division.

The ALE figures taken for Andhra are those for Zones I, III, and VII of the undivided Madras States. Coverage is almost identical with that of the two Census divisions.

TABLE A.6. PERCENTAGE DISTRIBUTION OF URBAN POPULATION BY "ECONOMIC STATUS": CENSUS OF 1951 AND NATIONAL SAMPLE SURVEY (9th Round 1955) FOR PART A STATES BEFORE 1956 REORGANIZATION

States	source	SSP's	ED's	NED's	not recorded	total	all males
							number of sample persons
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			(a) males				
Andhra*	census	45.02	5.04	49.94	—	100.00	1,602,133
	NSS	51.21	7.61	41.17	0.01	100.00	1,630
Assam	census	50.41	3.52	46.07	—	100.00	246,236
	NSS	44.96	4.69	50.28	0.07	100.00	516
Bihar	census	44.20	3.73	52.07	—	100.00	1,462,038
	NSS	48.68	7.51	43.81	—	100.00	1,727
Bombay	census	52.02	4.95	43.03	—	100.00	6,145,118
	NSS	50.04	4.97	44.81	0.18	100.00	7,396
Madhya Pradesh	census	48.92	6.50	44.58	—	100.00	1,494,962
	NSS	49.04	3.12	47.84	—	100.00	1,617
Madras*	census	44.25	4.27	51.48	—	100.00	4,021,325
	NSS	47.56	5.05	47.30	0.09	100.00	5,422
Orissa	census	51.12	6.05	42.83	—	100.00	315,876
	NSS	52.26	4.18	43.56	—	100.00	314
Punjab	census	45.71	7.86	46.43	—	100.00	1,297,963
	NSS	47.60	2.32	49.95	0.13	100.00	1,580
Uttar Pradesh	census	51.71	3.93	44.36	—	100.00	4,738,717
	NSS	50.65	3.75	45.59	0.01	100.00	5,996
West Bengal	census	59.97	1.52	38.51	—	100.00	3,714,028
	NSS	55.30	4.87	39.75	0.08	100.00	6,229
			(b) females				
Andhra*	census	7.58	3.80	88.62	—	100.00	1,585,935
	NSS	10.39	10.26	79.14	0.21	100.00	1,565
Assam	census	5.83	2.71	91.46	—	100.00	168,182
	NSS	2.86	22.73	74.36	0.05	100.00	384
Bihar	census	11.58	3.34	85.08	—	100.00	1,233,952
	NSS	9.18	6.59	84.18	0.05	100.00	1,341
Bombay	census	7.55	6.85	85.60	—	100.00	5,025,222
	NSS	8.10	8.26	83.39	0.25	100.00	6,014
Madhya Pradesh	census	8.05	10.48	81.47	—	100.00	1,382,377
	N.S.S.	8.97	10.15	80.81	0.07	100.00	1,433
Madras*	census	7.96	2.58	89.46	—	100.00	3,974,341
	NSS	8.85	6.75	84.30	0.10	100.00	5,068
Orissa	census	10.24	4.43	85.33	—	100.00	278,194
	NSS	14.30	5.81	79.89	—	100.00	285
Punjab	census	3.49	2.90	93.61	—	100.00	1,057,133
	NSS	5.56	3.28	90.83	0.33	100.00	1,366
Uttar Pradesh	census	4.87	2.67	92.46	—	100.00	3,886,982
	NSS	4.96	3.75	91.19	0.10	100.00	4,827
West Bengal	census	8.71	0.73	90.56	—	100.00	2,439,235
	NSS	6.55	2.74	90.37	0.34	100.00	4,492

* See notes on p. 174.

TABLE A.6. PERCENTAGE DISTRIBUTION OF URBAN POPULATION BY "ECONOMIC STATUS": CENSUS OF 1951 AND NATIONAL SAMPLE SURVEY (9th Round 1955) FOR PART A STATES BEFORE 1956 REORGANIZATION—(*continued*)

States	source	SSP's	ED's	NED's	not recorded	tota	all persons lnumber of sample persons
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			(c) persons				
Andhra*	census	26.39	4.43	69.18	—	100.00	3,188,068
	NSS	30.85	8.93	60.11	0.11	100.00	3,195
Assam	census	32.31	3.19	64.50	—	100.00	414,418
	NSS	25.07	13.21	61.66	0.06	100.00	900
Bihar	census	29.27	3.55	67.18	—	100.00	2,695,990
	NSS	30.61	7.09	62.28	0.02	100.00	3,068
Bombay	census	32.01	5.81	62.18	—	100.00	11,170,340
	NSS	30.32	6.52	62.95	0.21	100.00	13,410
Madhya Pradesh	census	28.29	8.41	62.30	—	100.00	2,877,339
	NSS	29.70	6.51	63.76	0.03	100.00	3,050
Madras*	census	26.21	3.43	70.36	—	100.00	7,995,666
	NSS	27.77	5.92	66.21	0.10	100.00	10,490
Orissa	census	31.98	5.29	62.73	—	100.00	594,070
	NSS	31.93	5.05	63.02	—	100.00	599
Punjab	census	26.76	5.64	67.60	—	100.00	2,355,096
	NSS	26.81	2.79	70.17	0.23	100.00	2,946
Uttar Pradesh	census	30.61	3.36	66.03	—	100.00	8,625,699
	NSS	29.88	3.75	66.32	0.05	100.00	10,823
West Bengal	census	39.65	1.21	59.14	—	100.00	6,153,263
	NSS	34.09	3.94	61.78	0.19	100.00	1,072

Source : Census ; Census of India 1951, Vol, I, Part II C, *Economic Tables* (*Rural and Urban Population*), Table B-I, pp, 26-29, 38-39.

NSS ; Indian Statistical Institute, National Sample Survey : No. 16, *Report on Employment and Unemployment* (May-November 1955), Delhi, 1959, Table 4 (4), p. 185.

General Note : "Economic Status" (or "Household Economic Status") is used in the Census of 1951 to denote the return of each individual as (a) a self-supporting person (SSP) ; (b) an earning dependent (ED) ; (c) a non-earning dependent (NED).

The National Sample Survey used three very similar categories : (a) earners ; (b) earning dependents ; (c) non-earning dependents.

*The figures taken from the Census for Andhra refer to the "North Madras" and "Madras Deccan" divisions of the former Madras State. The latter division includes the entire Bellary district. Chittoor, although a part of Andhra has been included in the figures for Madras since it was treated in the Census as part of the "South Madras" division.

TABLE A.7. PERCENTAGE OF RURAL AND URBAN POPULATION IN WORKING-AGE GROUP (15-64) COMPARED WITH PERCENTAGES RETURNED AS SELF-SUPPORTING AND EARNING DEPENDENTS IN CENSUS OF 1951 AND NATIONAL SAMPLE SURVEY (9th Round 1955) FOR PART A STATES BEFORE 1956 REORGANIZATION

States	item	source	males		females		persons	
			rural	urban	rural	urban	rural	urban
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Andhra*	Percentages in working ages	census sample	60.55	61.49	60.38	61.37	60.46	61.43
	Percentages of SSP's+ ED's	census	49.71	50.06	17.98	11.38	33.92	30.82
	Percentages of Earners +ED's	NSS	67.42	58.82	40.32	20.65	54.30	39.78
Assam	Percentages in working ages	census sample	55.19	66.02	55.53	54.31	54.41	61.33
	Percentages of SSPs'+ ED's	census	54.00	53.93	31.68	8.54	43.49	35.50
	Percentages of Earners +ED's	NSS	60.81	49.65	31.46	25.59	46.57	38.28
Bihar	Percentages in working ages	census sample	55.94	61.14	56.73	54.54	56.33	58.16
	Percentages of SSP's+ ED's	census	50.06	47.93	21.68	14.92	35.86	32.82
	Percentages of Earners +ED's	NSS	55.81	56.19	22.03	15.77	38.67	37.70
Bombay	Percentages in working ages	census sample	55.83	65.05	56.89	59.32	56.35	62.47
	Percentages of SSP's+ ED's	census	53.74	56.97	36.27	14.40	45.06	37.82
	Percentages of Earners +ED's	NSS	58.16	55.01	43.27	16.36	50.94	36.84
Madhya Pradesh	Percentages in working ages	census sample	57.96	61.21	58.35	59.25	58.15	60.28
	Percentages of SSP's+ ED's	census	64.94	55.42	52.14	18.53	58.52	36.70
	Percentages of Earners +ED's	NSS	62.52	52.16	51.91	19.12	57.21	36.21
Madras*	Percentages in working ages	census sample	59.80	62.97	60.61	61.95	60.21	62.47
	Percentages of SSP's + ED's	census	45.36	48.52	14.43	10.54	29.72	29.64
	Percentages of Earners + ED's	NSS NSS	61.76	52.61	39.39	15.60	50.46	33.69

* See notes on p. 176.

TABLE A.7. PERCENTAGE OF RUAL AND URBAN POPULATION IN WORKING-AGE GROUP (15-64) COMPARED WITH PERCENTAGES RETURNED AS SELF-SUPPORTING AND EARNING DEPENDENTS IN CENSUS OF 1951 AND NATIONAL SAMPLE SURVEY (9th Round 1955) FOR PART A STATES BEFORE 1956REORGANISATION—(*concluded*)

States	item	source	males		females		persons	
			rural	urban	rural	urban	rural	urban
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Orissa	Percentages in working ages	census sample	58.92	61.04	59.75	57.37	59.34	59.34
	Percentages of SSP's+ ED's	census	57.24	57.17	19.78	14.67	38.25	37.27
	Percentages of Earners +ED's	NSS	62.03	56.44	38.74	20.11	50.69	36.98
Punjab	Percentages in working ages	census sample	54.23	58.09	53.56	52.52	53.92	55.70
	Percentages of SSP's+ ED's	census	57.22	53.57	22.53	6.39	41.02	32.40
	Percentages of Earners +ED's	NSS	56.59	49.92	9.28	8.84	34.45	29.60
Uttar Pradesh	Percentages in working ages	census sample	58.28	62.02	57.60	58.22	57.96	60.32
	Percentages of SSP's+ ED's	census	59.57	55.64	26.75	7.54	43.80	33.97
	Percentages of Earners +ED's	NSS	58.27	54.40	22.41	8.71	40.95	33.63
West Bengal	Percentages in working ages	census sample	60.89	71.93	59.61	60.74	60.28	67.60
	Percentages of SSP's+ ED's	census	52.18	61.49	11.80	9.44	32.64	40.86
	Percentages of Earners +ED's	NSS	58.83	60.17	16.55	9.29	37.33	38.03

Source. Census Sample : Census of India, 1951, Vol. I, Part II-A, *Demographic Tables*, Table C-III pp. 186-187, 192-201, 208-209, 214-223 ; based on 10% Sample.

Census : Census of India 1951, Vol. I, Part II-C, *Economic Tables*, (*Rural and Urban* Population), Table B-II, pp. 2-5, 14-15, 26-29, 38-39.

National Sample Survey : No. 16, *Employment and Unemployment* (May-November 1955), Delhi, 1959, Tables 2(2) and 4(4), pp. 125 and 185.

Andhra* and Madras* : The figures taken from the Census for Andhra refer to the "North Madras" and "Madras Deccan" divisions of the former Madras State. The latter divisoion includes the entire Bellary district. Chittoor, although a part of Andhra, has been included in the figures for Madras since it was treated in the Census as part of the "South Madras" Division.

Self-supporting persons (SSP's) and Earning dependents (ED's) were the two classifications used in the Census of 1951 to denote persons with occupation or income, as distinguished from those completely dependent on others. The equivalent terms employed in the National Sample Survey are Earners and Earning Dependents.

TABLE A.8. PERCENTAGE DISTRIBUTION OF OCCUPIED POPULATION IN AGRICULTURE AND OTHER OCCUPATIONS, CENSUS OF 1951

States divisions	all males (000)	percentage occupied	SSP's +ED's (000)	owner cultivators	tenant cultivators	cultivating labourers	all other occupations	rent receivers
			(a) males					
Andhra								
Coastal-Andhra	7,212	50.8	3,663	33.4	7.1	26.1	32.2	1.2
Telengana	6,415	60.2	3,861*	31.6	7.1	23.0	37.5	0.7
Rayalaseema	2,572	46.9	1,207	42.8	4.8	14.8	40.0	1.6
Assam								
Valley	4,179	54.0	2,256	48.0	13.9	3.0	34.7	0.4
Hills	633	54.2	343	71.4	3.8	3.5	20.7	0.6
Manipur	284	53.2	151	76.6	9.9	—	19.9	2.6
Tripura	336	55.4	186	52.1	8.6	8.6	29.6	1.1
Bihar								
North Bihar	9,001	49.9	4,493	45.4	11.9	30.2	11.8	0.7
South Bihar	5,689	46.9	2,669	47.0	7.6	21.5	23.0	0.9
Chhota Nagpur	5,534	52.9	2,930	67.6	26.9	9.2	20.2	0.3
Gujarat								
Gujarat	5,885	53.1	3,125	37.5	8.8	12.6	40.0	1.0
Saurashtra	2,094	53.5	1,120	32.1	7.8	8.1	50.6	1.3
Kutch	273	55.3	151	26.5	8.6	6.6	56.3	2.0
Kerala								
Travancore-Cochin	4,621	49.7	2,298	20.4	6.4	22.3	50.4	0.5
Malabar	3,319	44.5	1,476	6.4	18.3	20.0	54.1	1.2
Madhya Pradesh								
Gwalior	910	56.6	515	48.0	17.5	5.4	28.0	1.1
Malwa	2,385	57.1	1,362	38.9	9.1	16.4	35.2	0.5
Dhar-Jhabua-Nimar	839	56.5	474	54.4	7.8	17.1	20.5	0.2
Bhopal	438	56.6	248	33.5	6.8	20.6	37.1	2.0
Jabalpur-Sagar	2,784	62.1	1,729	37.1	3.9	26.6	31.6	0.8
Chhattisgar	5,056	65.4	3.305	51.6	2.6	25.7	19.7	0.4
Bundelkhand	1.833	59.1	1,084	58.9	5.8	19.1	15.6	0.6
Madras								
Tamilnad	15,315	46.4	7,104	34.4	7.7	17.0	39.8	1.1
Maharashtra								
Greater Bombay	1,779	67.7	1,204	0.1	0.1	0.1	99.5	0.2
Konkan	2,274	52.6	1,197	25.3	28.7	7.3	38.1	0.7
Deccan	6,284	53.3	3,350	46.8	4.1	14.8	33.4	0.9

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*The percentages for Telengana have been calculated not on the total occupied population of 3,861 males but on a figure of 3,697 males since the returns of own occupation of 164 male earning dependents were missing.

TABLE A.8. PERCENTAGE DISTRIBUTION OF OCCUPIED POPULATION IN AGRICULTURE AND OTHER OCCUPATIONS, CENSUS OF 1951—(*continued*)

States divisions	all males (000)	percentage occupied	SSP's +ED's (000)	owner cultivators	tenant cultivators	cultivating labourers	all other occupations	rent receivers
Maharashtra (contd.)								
Berar-Nagpur	2,822	62.0	1,747	20.6	5.6	41.7	31.1	1.0
Marathwada	3,016	58.4	1,761*	38.4	5.3	28.7	26.0	1.6
Mysore								
Mysore State	4,657	47.7	2,223	50.1	5.1	8.0	35.6	1.2
Coorg	125	55.2	69	21.7	7.2	11.6	56.5	2.9
North Karnatak	2,392	55.4	1,326	40.5	11.0	18.8	28.3	1.4
Orissa								
Coastal	3,271	56.3	1,842	46.5	7.8	14.1	30.5	1.1
Inland	3,972	58.0	2,304	55.3	4.0	17.4	22.9	0.4
Punjab								
Punjab Plain	6,139	56.1	3,444	33.6	15.5	10.0	39.0	1.9
Patiala	1,895	59.7	1,131	47.9	11.4	10.2	28.5	2.0
Punjab Hills	509	61.3	312	63.8	8.0	1.9	25.3	1.0
Delhi	987	58.9	581	5.8	0.7	1.4	92.1	—
Himachal	580	67.2	390	79.0	7.7	1.8	11.0	0.5
Rajasthan								
Jaipur-Alwar	3,448	62.1	2,140	43.1	20.6	4.4	31.0	0.9
Ajmer	360	60.8	219	32.9	3.6	8.2	53.9	1.4
Jodhpur-Bikaner	2,416	58.2	1,406	24.0	41.3	3.8	30.1	0.7
Mewar	1,062	60.2	639	65.4	6.1	3.8	24.4	0.3
Kotah-Bundi	1,036	62.4	646	56.5	2.9	9.1	29.9	1.5
Uttar Pradesh								
Kumaon-Garhwal	1,284	58.5	751	65.8	4.7	1.7	27.7	0.1
East U.P.	9,037	58.3	5,268	67.3	6.4	7.4	18.6	0.3
Oudh	8,451	59.5	5,030	61.2	5.6	5.4	26.9	0.8
West U.P.	12,312	59.1	7,274	56.6	3.6	5.9	33.1	0.8
South U.P.	2,015	59.9	1,207	54.2	6.8	11.6	26.7	0.7
West Bengal								
Darjeeling-Duars	1,102	54.2	597	23.3	20.6	4.2	51.4	0.5
West Bengal Plain	12,243	54.8	6,712	23.5	9.3	15.5	51.3	0.4
Chandernagore	28	55.0	16	—	—	—	93.8	6.4
Sikkim	72	61.1	44	52.3	4.5	27.3	15.9	—

*The percentages for Marathwada have been calculated not on the total occupied population of 1,761 males but on a figure of 1,528 males since the returns of own occupation of 233 male earning dependents were missing.

Source :Census of India 1951, Vol. I, Part II-B, *Economic Tables*, pp. 2-14, 26-40, 90-120.

TABLE A.8. PERCENTAGE DISTRIBUTION OF OCCUPIED POPULATION IN AGRICULTURE AND OTHER OCCUPATIONS, CENSUS OF 1951—(*continued*)

States divisions	all females (000)	percentage occupied	SSP's +ED's (000)	owner cultivators	tenant cultivators	cultivating labourers	all other occupations	rent receivers
				(b) females				
Andhra								
Coastal Andhra	7,221	16.7	1,209	19.2	3.1	48.2	26.1	3.4
Telengana	6,294	30.9	1,942*	12.4	1.9	62.8	21.6	1.2
Rayalaseema	2,465	17.4	428	27.6	3.0	32.2	34.1	3.0
Assam								
Valley	3,626	28.8	1,043	37.1	9.8	3.2	49.1	0.8
Hills	605	42.8	259	78.8	3.9	5.4	10.8	1.1
Manipur	294	51.0	150	39.3	5.3	—	54.0	1.3
Tripura	303	29.7	90	53.3	7.7	10.0	26.7	2.2
Bihar								
North Bihar	9,117	18.3	1,665	42.0	11.3	35.5	10.4	0.8
South Bihar	5,552	21.6	1,200	44.3	7.7	27.8	18.2	2.0
Chhota Nagpur	5,333	26.0	1,385	68.0	3.5	14.7	13.2	0.6
Gujarat								
Gujarat	5,512	29.4	1,619	37.7	7.3	30.8	22.3	1.9
Saurashtra	2,043	29.7	607	30.0	6.8	29.8	32.1	1.0
Kutch	295	30.8	91	19.8	5.5	23.1	51.6	—
Kerala								
Travancore-Cochin	4,660	22.7	1,057	13.8	2.5	27.1	54.5	2.1
Malabar	3,500	15.3	534	5.4	11.6	35.2	44.0	4.1
Madhya Pradesh								
Gwalior	782	11.4	89	30.7	15.9	21.6	28.4	3.4
Malwa	2,231	23.5	524	22.1	8.8	47.9	19.8	1.3
Dhar-Jhabua-Nimar	808	39.5	319	45.5	8.1	33.9	11.3	1.3
Bhopal	399	24.8	99	28.3	8.1	38.4	23.2	2.0
Jabalpur-Sagar	2,706	41.2	1,114	17.1	1.0	65.0	15.8	1.2
Chhattisgarh	5,143	54.0	2,777	22.7	1.3	59.1	16.2	0.7
Bundelkhand	1,742	32.5	566	45.8	6.9	31.4	15.2	0.7
Madras								
Tamilnad	15,410	13.2	2,039	23.1	4.0	37.1	32.3	3.5

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*The percentages for Telengana have been calculated not on the total occupied population of 1942 females but on a figure of 1,739 females since the returns of own occupation of 203 female earning dependents were missing.

TABLE A.8. PERCENTAGE DISTRIBUTION OF OCCUPIED POPULATION IN AGRICULTURE AND OTHER OCCUPATIONS, CENSUS OF 1951—(*continued*)

States divisions	all females (000)	percentage occupied	SSP's + ED's (000)	owner cultivators	tenant cultivators	cultivating labourers	all other occupations	rent receivers
Maharashtra								
Greater Bombay	1,060	11.3	120	—	—	—	97.5	2.5
Konkan	2,382	34.9	832	28.5	31.7	16.3	22.5	1.0
Deccan	6,081	30.8	1,870	47.9	4.0	30.6	15.9	1.6
Berar-Nagpur	2,735	42.6	1,164	4.9	0.8	83.2	10.0	1.1
Marathwada	2,930	32.7	957*	14.3	2.9	63.9	16.9	2.0
Mysore								
Mysore State	4,418	10.0	444	30.9	4.1	20.0	37.4	7.7
Coorg	104	22.1	23	8.7	4.3	13.0	56.5	17.4
North Karnatak	2,306	32.5	749	35.9	10.0	35.6	16.3	2.3
Orissa								
Coastal	3,402	14.5	494	26.9	4.1	16.6	49.4	3.0
Inland	4,001	23.9	956	31.0	2.5	27.8	37.6	1.0
Punjab								
Punjab Plain	5,278	17.4	920	35.5	12.4	19.6	28.8	3.7
Patiala	1,599	14.4	230	53.0	11.3	12.6	20.4	2.6
Punjab Hills	464	43.7	203	46.8	24.6	8.4	17.7	2.5
Delhi	758	7.7	58	13.8	—	10.3	70.7	5.2
Himachal	530	51.1	271	81.2	5.2	3.7	9.6	0.3
Rajasthan								
Jaipur-Alwar	3,137	40.7	1,279	48.0	24.8	12.9	25.7	1.5
Ajmer	333	36.6	122	32.0	2.4	34.4	28.7	2.5
Jodhpur-Bikaner	2,188	33.5	734	24.1	48.8	6.8	19.5	0.8
Mewar	1,032	44.4	458	68.1	4.4	8.1	17.9	1.5
Kotah-Bundi	972	42.2	410	57.3	2.2	19.0	19.3	2.2
Uttar Pradesh								
Kumaon-Garhwal	1,238	50.7	628	88.2	5.1	1.0	5.7	—
East U.P.	8,850	35.3	3,125	65.4	6.5	12.1	15.3	0.7
Oudh	7,679	27.8	3,132	64.6	6.1	10.2	18.0	1.1
West U.P.	10,459	6.7	699	37.5	2.0	4.4	49.6	6.4
South U.P.	1,891	38.3	724	53.9	6.8	19.1	18.8	1.5
West Bengal								
Darjeeling-Duars	929	18.5	172	9.3	6.4	2.9	79.7	1.7
West Bengal Plain	10,536	10.7	1,123	18.3	6.3	19.9	54.4	1.0
Chandernagore	22	9.0	2	—	—	—	100.0	—
Sikkim	66	53.0	35	11.4	8.6	74.3	2.9	2.8

*The percentages for Marathwada have been calculated not on the total occupied population of 957 females but on a figure of 575 females since the returns of own occupation of 382 female earning dependents were missing.

Source : Census of India 1951, Vol. I, Part II-B, *Economic Tables*, pp. 2-14, 26-40, 90-120.

TABLE A.8. PERCENTAGE DISTRIBUTION OF OCCUPIED POPULATION IN AGRICULTURE AND OTHER OCCUPATIONS, CENSUS OF 1951—*(continued)*

States divisions	all persons (000)	percentage occupied	SSP's +ED's (000)	owner cultivators	tenant cultivators	cultivating labourers	all other occupations	rent receivers
				(c) persons				
Andhra								
Coastal Andhra	14,433	33.8	4,872	29.9	6.1	31.5	30.7	1.8
Telengana	12,709	45.7	5,803*	25.5	5.4	35.7	32.4	0.9
Rayalaseema	5,038	32.4	1,634	38.8	4.3	19.4	35.5	2.0
Assam								
Valley	7,805	42.3	3,299	44.5	12.6	3.1	39.3	0.5
Hills	1,238	48.6	602	74.6	3.8	4.3	16.5	0.8
Manipur	578	52.1	301	53.5	7.6	—	36.9	2.0
Tripura	639	43.2	276	52.5	8.3	9.1	28.6	1.5
Bihar								
North Bihar	18,118	34.0	6,158	44.5	11.8	31.6	11.4	0.7
South Bihar	11,241	34.4	3,869	46.2	7.6	23.4	21.5	1.3
Chhota Nagpur	10,866	39.7	4,315	67.8	3.0	10.9	17.9	0.4
Gujarat								
Gujarat	11,397	41.6	4,744	37.6	8.3	18.8	34.0	1.3
Saurashtra	4,137	41.7	1,727	31.5	7.4	15.9	44.0	1.2
Kutch	568	42.6	242	24.0	7.4	12.8	54.5	1.2
Kerala								
Travancore-Cochin	9,280	36.2	3,353	18.3	5.1	23.9	51.7	1.0
Malabar	6,819	29.5	2,009	5.9	16.6	24.1	51.4	2.0
Madhya Pradesh								
Gwalior	1,692	35.5	603	45.5	17.2	7.8	28.0	1 5
Malwa	4,616	40.9	1,886	34.2	9.0	25.1	30.9	0.8
Dhar-Jhabua-Nimar	1,647	48.1	793	50.8	7.9	23.8	16.8	0.6
Bhopal	836	41.4	347	32.0	7.2	25.6	33.1	2.0
Jabalpur-Sagar	5,490	51.8	2,843	29.3	2.7	41.7	25.5	0.9
Chhattisgarh	10,199	59.6	6,082	38.4	2.0	41.0	18.1	0.5
Bundelkhand	3,575	46.2	1,650	54.5	6.1	23.3	15.5	0.6
Madras								
Tamilnad	30,726	29.8	9,143	31.9	6.9	21.5	38.1	1.7
Maharashtra								
Greater Bombay	2,839	46.6	1,324	0.1	0.1	0.1	99.4	0.4
Konkan	4,657	43.5	2,028	26.6	30.0	11.0	31.7	0.8
Deccan	12,365	42.2	5,221	47.2	4.1	20.5	27.1	1.1

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*The percentages for Telengana have been calculated not on the total occupied population of 5,803 persons but on a figure of 5,436 persons since the returns of own occupation of 367 earning dependents were missing.

TABLE A.8. PERCENTAGE DISTRIBUTION OF OCCUPIED POPULATION IN AGRICULTURE AND OTHER OCCUPATIONS, CENSUS OF 1951—(*concluded*)

States divisions	all persons (000)	percentage occupied	SSP's +ED's (000)	owner cultivators	tenant cultivators	cultivating labourers	all other occupations	rent receivers
Maharashtra (contd.)								
Berar-Nagpur	5,558	52.4	2,911	14.4	3.7	58.3	22.6	1.0
Marathwada	5,946	45.7	2,718*	31.7	4.6	38.5	23.5	1.7
Mysore								
Mysore State	9,075	29.4	2,667	46.9	4.9	10.0	35.9	2.2
Coorg	229	40.2	92	18.5	6.5	12.0	56.5	6.5
North Karnatak	4,698	44.2	2,075	38.8	10.7	24.9	23.9	1.7
Orissa								
Coastal	6,673	35.0	2,336	42.3	7.0	14.6	34.5	1.6
Inland	7,973	40.9	3,260	48.2	3.5	20.5	27.2	0.6
Punjab								
Punjab Plain	11,417	38.2	4,364	34.1	14.8	12.0	36.8	2.3
Patiala	3,494	39.0	1,361	48.8	11.4	10.6	27.1	2.1
Punjab Hills	973	52.9	515	57.1	14.6	4.5	22.3	1.5
Delhi	1,745	36.6	639	6.6	0.6	2.2	90.1	0.5
Himachal	1,110	59.5	661	79.9	6.6	2.6	10.4	0.5
Rajasthan								
Jaipur-Alwar	6,585	51.9	3,419	42.9	21.1	7.0	27.9	1.1
Ajmer	693	49.2	341	32.5	3.2	17.6	44.9	1.8
Jodhpur-Bikaner	4,604	46.5	2,139	24.1	43.9	4.9	26.4	0.7
Mewar	2,093	52.4	1,097	66.5	5.4	5.6	21.7	0.8
Kotah-Bundi	2,008	52.6	1,056	56.8	2.6	13.0	25.8	1.8
Uttar Pradesh								
Kumaon-Garhwal	2,522	54.7	1,379	76.0	4.8	1.4	17.7	0.1
East U.P.	17,887	46.9	8,393	66.5	6.5	9.2	17.3	0.5
Oudh	16,130	44.4	7,162	62.2	5.8	6.9	24.2	0.9
West U.P.	22,771	35.0	7,973	54.9	3.5	5.8	34.6	1.3
South U.P.	3,906	49.4	1,931	54.1	6.8	14.4	23.7	1.0
West Bengal								
Darjeeling-Duars	2,031	37.9	769	20.2	17.4	3.9	57.7	0.8
West Bengal Plain	22,779	34.4	7,835	22.8	8.9	16.2	51.7	0.4
Chandernagore	50	35.0	17	—	—	—	94.4	5.6
Sikkim	138	57.2	79	34.2	6.3	48.1	10.1	1.3

*The percentage for Marathwada have been calculated not on the total occupied population of 2,718 persons but on a figure of 2,115 persons since the returns of own occupation of 603 earning dependents were missing.

Source : Census of India, 1951, Vol. I, Part II-B, *Economic Tables*, pp. 2-14, 26-40, 90-120.

Definitions : Percentage occupied : Number of self-supporting persons and earning dependents. Owner cultivators : Self-supporting persons in Class I, plus earning dependents with own occupation in Class I, plus rent receivers with subsidiary occupation in Class I. Tenant cultivators : Self-supporting persons in Class II, plus earning dependents with own occupation in Class II, plus rent receivers with subsidiary occupation in Class II. Cultivating labourers : Self-supporting persons in Class III, plus earning dependents with own occupation in Class III, plus rent receivers with subsidiary occupation in Class III. All other occupations : Self-supporting persons in Classes V, VI, VII, and VIII ; plus earning dependents with own occupation in these classes plus rent receivers with subsidiary occupations in these classes. Rent receivers : Self-supporting persons in Class IV with no subsidiary occupation plus earning dependents with own occupation in Class IV.

TABLE A.9. PERCENTAGE DISTRIBUTION OF SELF-SUPPORTING PERSONS (CENSUS OF 1951) AND EARNERS (AGRICULTURAL LABOUR ENQUIRY) BY PRINCIPAL OCCUPATION FOR 17 STATES (RURAL POPULATION)

States*	source	self-supporting persons (census) and earners (agricultural labour enquiry)								
		all		agricultural						non-agricultura
					owners and tenants				labourers	
		number	percentage	all agricultural	all	owner cultivators	tenant cultivators	rent receivers		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Assam	census	2,478,368	100.0	65.3	62.9	50.9	11.1	0.9	2.4	34.7
	ALE	2,528	100.0	73.2	60.8	43.5	17.3	—	12.4	26.8
Bihar	census	11,917,649	100.0	91.0	67.6	58.9	8.1	0.6	23.4	9.0
	ALE	17,151	100.0	74.9	26.6	1.7	24.9	—	48.3	25.1
Bombay	census	6,216,610	100.0	80.6	66.1	51.1	12.5	2.5	14.5	19.4
	ALE	10,611	100.0	84.6	53.2	37.7	15.5	—	31.4	15.4
Hyderabad	census	3,836,699	100.0	78.1	54.1	43.2	7.9	3.0	24.0	21.9
	ALE	9,841	100.0	77.9	25.9	22.3	3.6	—	52.0	22.1
Madhya Bharat	census	2,630,478	100.0	68.1	55.3	45.8	8.6	0.9	12.8	31.9
	ALE	3,242	100.0	80.7	49.2	30.4	18.8	—	31.5	19.3
Madhya Pradesh	census	5,596,182	100.0	84.5	55.1	48.6	4.5	2.0	29.4	15.5
	ALE	8,878	100.0	82.2	31.0	4.5	26.5	—	51.2	17.8
Madras	census	12,025,620	100.0	75.6	50.8	38.7	9.7	2.4	24.8	24.4
	ALE	30,061	100.0	79.9	19.0	14.1	4.9	—	60.9	20.1

* As of 1951.

TABLE A.9. PERCENTAGE DISTRIBUTION OF SELF-SUPPORTING PERSONS (CENSUS OF 1951) AND EARNERS (AGRICULTURAL LABOUR ENQUIRY) BY PRINCIPAL OCCUPATION FOR 17 STATES—(*continued*)

States*	source	self-supporting persons (census) and earners (agricultural labour enquiry)								
		all		agricultural						non-agricultural
					owners and tenants				labourers	
		number	percentage	all agricultural	all	owner cultivators	tenant cultivators	rent receivers		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Mysore	census	1,803,161	100.0	85.3	73.8	64.6	5.6	3.6	11.5	14.7
	ALE	3,279	100.0	86.9	36.4	31.5	4.9	—	50.5	13.1
Orissa	census	3,992,481	100.0	80.2	65.5	58.2	5.7	1.6	14.7	19.8
	ALE	4,806	100.0	79.6	30.6	27.6	3.0	—	49.0	20.4
PEPSU	census	852,317	100.0	84.9	72.6	56.7	13.0	2.9	12.3	15.1
	ALE	2,698	100.0	69.7	53.6	39.6	14.0	—	16.1	36.3
Punjab	census	2,680,629	100.0	77.7	67.6	46.4	18.5	2.7	10.1	22.3
	ALE	6,760	100.0	58.3	46.9	33.5	13.4	—	11.4	41.7
Rajasthan	census	4,887,294	100.0	84.0	80.1	50.1	28.5	1.5	3.9	20.0
	ALE	3,602	100.0	79.2	65.6	32.5	33.1	—	13.6	20.8
Saurashtra	census	647,624	100.0	63.4	56.4	42.9	11.1	2.4	7.0	36.6
	ALE	1,925	100.0	65.5	31.4	19.8	11.6	—	34.1	34.5
Travancore-Cochin	census	2,215,948	100.0	57.0	31.0	23.3	6.6	1.1	26.0	43.0
	ALE	12,452	100.0	57.6	14.7	10.2	4.5	—	42.9	42.4
Uttar Pradesh	census	16,619,599	100.0	82.0	74.2	67.1	5.7	1.4	7.8	18.0
	ALE	17,910	100.0	71.3	54.2	6.5	47.7	—	17.1	28.7
Vindhya Pradesh	census	1,027,707	100.0	91.7	73.8	62.7	7.5	0.6	20.9	8.3
	ALE	1,779	100.0	80.2	49.5	43.1	6.4	—	30.7	19.8
West Bengal	census	5,377,010	100.0	67.4	48.5	34.3	13.7	0.5	18.9	32.6
	ALE	10,493	100.0	64.2	37.9	7.1	30.8	—	26.3	35.8

Source : Census—Census of India 1951, Vol. I, Part II-C, *Economic Tables.* pp. 4-14, Agricultural Labour Enquiry—Government of India—Ministry of Labour, *Rural Manpower and Occupational Structure,* (Delhi) 1954, Table No. 6 for all States.

* As of 1951.

TABLE A.10. PERCENTAGE DISTRIBUTION OF SELF-SUPPORTING PERSONS (CENSUS OF 1951) AND EARNERS (AGRICULTURAL LABOUR ENQUIRY) BY SINGLE AND COMBINED OCCUPATIONS IN CULTIVATION, AGRICULTURAL LABOUR, AND NON-AGRICULTURE FOR SEVENTEEN STATES

States	source	census ALE self-supporting persons earners				solely or partly engaged in cultivation			solely or partly engaged in agricultural labour			solely or partly engaged in non-agriculture		
		total		with single occupation	with combined occupation	total	as sole occupation	with other occupation	total	as sole occupation	with other occupation	total	with single occupation	with combined occupation
		number	percentage											
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Assam	census	2,612,286	100.0	87.5*	11.6*	62.3	52.1	10.2	2.7	2.0	0.7	44.5	33.4	11.1
	ALE	2,528	100.0	75.8	24.2	70.4	49.4	21.0	14.7	7.3	7.4	38.2	19.1	19.1
Bihar	census	12,706,699	100.0	88.4	11.0	65.4	56.3	9.1	25.5	20.7	4.8	18.9	11.4	7.5
	ALE	17,151	100.0	52.6	47.4	42.1	17.2	24.9	53.5	35.4	18.1	34.7	—	34.7
Bombay	census	9,792,261	100.0	87.1	10.9	45.2	36.7	8.5	12.5	9.4	3.1	49.7	41.0	8.7
	ALE	10,611	100.0	77.4	22.6	60.1	43.4	16.7	37.4	24.5	12.9	22.7	9.5	13.2
Hyderabad	census	2,811,189	100.0	82.9	14.4	45.2	34.1	11.1	23.4	19.0	4.4	41.7	29.8	11.9
	ALE	9,841	100.0	81.4	18.6	32.5	21.6	10.9	56.0	44.6	11.4	28.6	15.2	13.4
Madhya Bharat	census	2,518,318	100.0	86.6	12.4	59.2	49.8	9.4	16.2	12.8	3.4	34.5	24.0	10.5
	ALE	3,242	100.0	77.2	22.8	55.8	41.1	14.7	37.0	24.5	12.5	29.4	11.6	17.8
Madhya Pradesh	census	6,438,898	100.0	80.3	17.8	50.3	36.3	14.0	31.5	23.5	8.0	32.8	20.5	12.3
	ALE	8,878	100.0	74.6	25.4	37.0	21.7	15.3	58.7	42.1	16.6	28.7	10.8	17.9
Madras	census	14,962,541	100.0	89.4	8.2	41.8	35.8	6.0	22.7	19.9	2.8	40.2	33.7	6.5
	ALE	30,061	100.0	74.7	25.2	32.2	14.8	17.4	65.0	47.5	17.5	27.4	12.4	15.0
Mysore	census	2,360,576	100.0	86.4	10.3	56.1	47.6	8.5	10.1	8.7	1.4	39.6	30.1	9.5
	ALE	3,279	100.0	81.2	18.8	43.9	28.8	15.1	53.0	43.5	9.5	21.1	8.9	12.2
Orissa	census	4,182,456	100.0	75.8	22.6	64.4	45.8	18.6	17.9	12.2	5.7	36.7	17.8	18.9
	ALE	4,806	100.0	64.8	35.2	46.6	18.0	28.6	55.5	35.2	20.3	32.2	11.6	20.6
PEPSU	census	1,044,929	100.0	93.0	4.3	60.3	57.3	3.0	11.0	10.2	0.8	29.4	25.5	3.9
	ALE	2,698	100.0	90.7	9.3	56.9	50.2	6.7	16.9	15.2	1.7	34.0	25.3	8.7

TABLE A.10. PERCENTAGE DISTRIBUTION OF SELF SUPPORTING PERSONS (CENSUS OF 1951) AND EARNERS (AGRICULTURAL LABOUR ENQUIRY) BY SINGLE AND COMBINED OCCUPATIONS N CULTIVATION, AGRICULTURAL LABOUR, AND NON-AGRICULTURE FOR SEVENTEEN STATES—(*continued*)

States	source	census ALE self-supporting persons earners				solely or partly engaged in cultivation			solely or partly engaged in agricultural labour			solely or partly engaged in non-agriculture		
		total		with single occupation	with combined occupation	total	as sole occupation	with other occupation	total	as sole occupation	with other occupation	total	with single occupation	with combine occupation
		number	percentage											
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15
Punjab	census	3,310,828	100.0	91.6	6.1	54.8	50.7	4.1	9.1	8.1	1.0	38.4	32.8	5.6
	ALE	6,760	100.0	82.0	18.0	51.3	40.1	11.2	13.3	8.4	4.9	50.4	33.5	6.9
Rajasthan	census	5,665,469	100.0	85.5	13.1	72.6	61.7	10.9	5.2	3.2	2.0	32.3	20.6	11.7
	ALE	3,602	100.0	79.1	20.9	73.2	55.1	18.1	19.8	12.1	7.7	27.0	11.9	15.1
Saurashtra	census	974,055	100.0	92.1	6.1	39.8	37.2	2.6	5.8	4.8	1.0	55.7	50.1	5.6
	ALE	1,925	100.0	63.6	36.4	33.3	27.7	5.6	47.8	18.3	29.5	52.4	17.6	34.8
Travancore-Cochin	census	2,648,254	100.0	83.7	15.0	32.4	21.6	10.8	25.0	20.8	4.2	54.3	41.3	13.0
	ALE	12,452	100.0	81.4	18.6	30.4	13.7	16.7	43.6	35.0	8.6	44.4	32.7	11.7
Uttar Pradesh	census	19,259,510	100.0	85.7	12.9	66.2	54.9	11.3	8.7	6.1	2.6	35.5	24.7	10.8
	ALE	17,910	100.0	82.7	17.3	64.0	49.4	14.6	19.3	10.5	8.8	33.2	22.8	10.4
Vindhya Pradesh	census	1,126,115	100.0	86.5	12.9	67.1	56.0	11.1	21.3	18.3	3.0	23.4	12.2	11.2
	ALE	1,779	100.0	88.6	11.4	54.8	44.0	10.8	31.2	28.2	3.0	25.3	16.4	8.9
West Bengal	census	7,816,750	100.0	87.9	11.6	36.6	27.3	9.3	16.5	11.5	5.0	57.9	49.1	8.8
	ALE	10,493	100.0	82.0	18.0	46.5	32.1	14.4	28.2	22.9	5.3	42.6	27.0	15.6

Source : Census—Census of Inda 1951, Vol. I, Part II-B, *Economic Tables*, pp. 4-10, 1415, 46-47, 50-58, 62-63, 68-74, 82-89, 106-111, 114-121 ALE—Government of India—Ministry of Labour, *Rural Manpowr and Occupational Structure*—1954, Table No. 6, for all States.

Note : The Census percentages in columns (5) and (6) add up to slightly less than 100% since a small number of self-supporting persons in each State were returned as having no occupation as such but subsisting solely on receipts of rent. Thus the figures for Assam, 87.5 and 11.6, come to a total of 99.1. We read in Appendix Table 9 that the percentage of rent receivers recorded for this State was 0.9.

TABLE A.11. PERCENTAGE DISTRIBUTION OF RURAL POPULATION BY PRINCIPAL OCCUPATION OF HEAD OF HOUSEHOLD—CENSUS OF 1951 AND AGRICULTURAL LABOUR ENQUIRY

States and divisions	source	occupations									
		owners	tenants	non-cultivating holders	agricultural labour with land	all landholders	agricultural labour without land	all agricultural labourers	all agricultural occupations	other occupations	total population
Andhra											
Coastal Andhra	census	43.4	8.7	2.2	—	54.3	—	25.7	80.0	20.0	100.0
	ALE	26.5	5.2	—	23.8	55.5	26.5	50.3	82.0	18.0	100.0
Telengana	census	46.5	9.9	2.2	—	58.6	—	17.6	76.2	23.8	100.0
	ALE	32.6	3.5	—	24.6	60.7	18.0	42.6	78.7	21.3	100.0
Rayalaseema	census	53.5	5.5	2.7	—	61.7	—	15.3	77.1	22.9	100.0
	ALE	30.0	3.6	—	30.7	64.3	22.2	52.9	86.5	13.5	100.0
Assam											
Assam Valley	census	57.1	14.7	0.9	—	72.0	—	1.6	74.4	25.6	100.0
	ALE	57.9	19.3	—	7.0	84.2	2.2	9.2	86.4	13.6	100.0
Assam Hills	census	82.2	4.6	0.5	—	87.3	—	2.9	90.2	9.8	100.0
	ALE	50.5	24.7	—	4.1	79.3	4.2	8.3	83.5	16.5	100.0
Manipur	census	71.2	10.0	2.0	—	83.2	—	0.2	83.4	16.6	100.0
	ALE	54.7	26.3	—	0.4	81.4	0.1	0.4	81.5	18.5	100.0
Tripura	census	63.6	9.3	1.6	—	74.5	—	5.2	79.7	20.3	100.0
	ALE	68.3	13.2	—	1.4	82.9	12.5	13.9	95.4	4.6	100.0
Bihar											
North Bihar	census	49.5	12.0	0.5	—	62.0	—	30.5	92.5	7.5	100.0
	ALE	4.6	42.0	—	22.8	69.4	12.4	35.2	81.8	18.2	100.0
South Bihar	census	53.0	9.1	0.8	—	62.9	—	24.3	87.2	12.8	100.0
	ALE	3.1	51.4	—	20.3	64.8	7.4	27.8	82.3	17.7	100.0
Chhota Nagpur	census	79.3	2.8	0.4	—	82.5	—	8.2	90.7	9.3	100.0
	ALE	2.0	37.4	—	31.3	70.7	11.7	43.0	82.4	17.6	100.0

TABLE A.11. PERCENTAGE DISTRIBUTION OF RURAL POPULATION BY PRINCIPAL OCCUPATION OF HEAD OF HOUSEHOLD—CENSUS OF 1951 AND AGRICULTURAL LABOUR ENQUIRY—(*continued*)

States and divisions	source	occupations									
		owners	tenants	non-cultivating holders	agricultural labour with land	all landholders	agricultural labour without land	all agricultural labourers	all agricultural occupations	other occupations	total population
Gujarat											
Gujarat	census	54.2	12.3	2.2	—	68.7	—	10.4	79.1	20.9	100.0
	ALE	45.7	24.7	—	1.9	72.3	11.9	13.9	84.9	15.8	100.0
Saurashtra	census	44.9	12.0	2.3	—	59.2	—	5.2	64.4	35.6	100.0
	ALE	32.2	20.7	—	2.3	55.2	15.2	17.5	70.4	29.6	100.0
Kutch	census	33.5	11.4	1.9	—	46.8	—	3.4	50.2	49.8	100.0
	ALE	32.4	8.0	—	3.5	43.9	13.0	16.5	56.9	43.1	100.0
Jammu-Kashmir	census				not taken						
	ALE	69.4	14.7	—	3.0	87.1	0.5	3.5	87.6	12.4	100.0
Kerala											
Travancore-Cochin	census	29.6	8.0	1.0	—	38.6	—	22.0	60.6	39.4	100.0
	ALE	21.4	10.0	—	20.5	51.9	15.8	36.4	67.7	32.2	100.0
Malabar	census	8.8	25.5	2.4	—	36.7	—	22.6	59.3	40.7	100.0
	ALE	15.3	15.5	—	22.7	53.5	14.6	37.3	68.1	31.9	100.0
Madhya Pradesh											
Gwalior	census	64.0	20.2	0.7	—	84.9	—	4.5	89.4	10.6	100.0
	ALE	27.5	52.7	—	4.4	84.6	5.7	10.0	90.3	9.7	100.0
Malwa	census	56.6	10.7	1.1	—	68.4	—	15.5	83.9	16.1	100.0
	ALE	40.9	13.4	—	12.2	66.5	14.3	26.5	80.8	19.2	100.0
Dhar-Jhabua-Nimar	census	67.2	7.4	0.9	—	75.5	—	13.2	88.7	11.3	100.0
	ALE	59.9	6.5	—	6.6	73.0	12.6	19.2	85.6	14.4	100.0
Bhopal	census	44.0	8.3	1.4	—	53.7	—	23.7	77.4	22.6	100.0
	ALE	41.2	4.7	—	9.2	55.1	35.3	44.5	90.4	9.6	100.0
Jabalpur-Sagar	census	54.1	5.1	2.1	—	61.3	—	20.2	81.5	18.5	100.0
	ALE	5.3	46.0	—	7.6	58.9	16.7	24.3	75.6	24.4	100.0
Chhattisgarh	census	65.9	3.3	1.1	—	70.3	—	17.3	87.6	12.4	100.0
	ALE	5.0	54.5	—	17.9	77.4	12.9	30.8	90.3	9.7	100.0
Bundelkhand	census	66.7	6.7	0.5	—	73.9	—	18.7	92.6	7.4	100.0
	ALE	68.3	13.2	—	1.4	82.9	12.5	13.9	95.4	4.5	100.0

TABLE A.11. PERCENTAGE DISTRIBUTION OF RURAL POPULATION BY PRINCIPAL OCCUPATION OF HEAD OF HOUSEHOLD—CENSUS OF 1951 AND AGRICULTURAL LABOUR ENQUIRY—(*continued*)

States and divisions	source	occupations									
		owners	tenants	non-cultivating holders	agricultural labour with land	all landholders	agricultural labour without land	all agricultural labourers	all agricultural occupations	other occupations	total population
Madras											
Tamilnad	census	47.1	10.0	1.8	—	58.8	—	20.3	79.1	20.9	100.0
	ALE	22.6	3.8	—	35.8	62.2	20.7	56.5	82.9	17.1	100.0
Maharashtra											
Konkan	census	33.7	35.3	1.5	—	70.5	—	5.9	76.3	23.7	100.0
	ALE	43.2	32.1	—	14.2	89.5	3.8	18.0	93.3	6.7	100.0
Deccan	census	65.5	4.7	2.1	—	72.3	—	13.2	85.5	14.5	100.0
	ALE	60.1	7.9	—	15.4	83.4	8.1	23.5	91.5	8.5	100.0
Berar-Nagpur	census	34.9	8.8	2.7	—	46.4	—	38.4	84.8	15.2	100.0
	ALE	14.1	19.9	—	19.3	53.3	38.3	57.6	91.6	8.4	100.0
Marathwada	census	53.0	5.8	3.5	—	62.3	—	24.6	86.9	13.1	100.0
	ALE	42.2	5.3	—	16.4	63.9	21.2	37.6	85.1	14.9	100.0
Mysore											
Mysore State	census	70.7	5.7	3.0	—	79.4	—	8.4	87.8	12.2	100.0
	ALE	47.3	6.1	—	27.6	81.0	10.5	38.1	91.5	8.5	100.0
Coorg	census	36.3	10.7	3.0	—	50.0	—	11.4	61.4	38.6	100.0
	ALE	50.4	23.0	—	7.5	80.9	4.4	11.9	85.3	14.7	100.0
North Karnatak	census	54.3	12.6	3.2	—	70.1	—	17.4	87.5	12.5	100.0
	ALE	49.7	16.1	—	16.0	81.8	7.4	23.4	89.2	10.8	100.0
Orissa											
Coastal	census	56.3	8.5	2.3	—	67.1	—	11.9	79.0	21.0	100.0
	ALE	41.8	5.7	—	27.7	75.2	8.4	36.1	83.6	16.4	100.0
Inland	census	66.2	4.2	0.7	—	71.1	—	13.4	84.5	16.6	100.0
	ALE	42.8	2.4	—	20.1	65.3	23.2	43.2	88.5	11.5	100.0
Punjab											
Punjab Plain	census	44.0	20.0	2.4	—	66.3	—	10.0	76.3	23.7	100.0
	ALE	46.1	19.2	—	1.6	66.9	7.4	9.0	74.3	25.7	100.0

TABLE A.11. PERCENTAGE DISTRIBUTION OF RURAL POPULATION BY PRINCIPAL OCCUPATION OF HEAD OF HOUSEHOLD—CENSUS OF 1951 AND AGRICULTURAL LABOUR ENQUIRY—*(continued)*

States and divisions	source	occupations									
		owners	tenants	non-cultivating holders	agricultural labour with land	all landholders	agricultural labour without land	all agricultural labourers	all agricultural occupations	other occupations	total population
Punjab (Contd.)											
Patiala	census	57.2	13.1	2.6	—	72.9	—	12.1	85.0	15.0	100.0
	ALE	47.6	18.3	—	0.8	66.7	11.7	12.5	78.4	21.6	100.0
Punjab Hills	census	75.9	9.9	1.7	—	87.5	—	1.8	89.3	10.7	100.0
	ALE	separate figures not available									
Delhi	census	37.2	4.4	1.1	—	42.7	—	9.2	51.9	48.1	100.0
	ALE	38.0	9.9	—	0.4	48.3	3.7	4.1	52.0	48.0	100.0
Himachal	census	86.4	7.3	0.7	—	94.5	—	1.0	95.5	4.5	100.0
	ALE	48.2	26.9	—	5.1	80.2	2.7	7.7	82.9	17.1	100.0
Rajasthan											
Jaipur-Alwar	census	52.6	25.1	1.7	—	79.4	—	2.4	81.8	18.2	100.0
	ALE	24.2	48.0	—	5.2	77.4	5.8	11.0	83.2	16.8	100.0
Ajmer	census	64.3	5.1	3.2	—	72.6	—	4.8	77.4	22.6	100.0
	ALE	28.4	45.0	—	6.0	73.4	2.8	8.7	82.1	17.9	100.0
Jodhpur-Bikaner	census	28.8	48.2	1.2	—	78.2	—	3.6	81.8	18.2	100.0
	ALE	33.3	44.5	—	4.9	82.7	2.8	7.7	85.5	14.5	100.0
Mewar	census	74.4	6.7	1.8	—	82.9	—	2.0	84.9	15.1	100.0
	ALE	58.6	22.3	—	0.4	81.3	1.1	1.5	82.4	17.6	100.0
Kotah-Bundi	census	67.5	3.3	2.9	—	73.7	—	8.6	82.3	17.7	100.0
	ALE	69.6	3.5	—	6.7	79.8	11.2	17.9	91.0	9.0	100.0

TABLE A.11. PERCENTAGE DISTRIBUTION OF RURAL POPULATION BY PRINCIPAL OCCUPATION OF HEAD OF HOUSEHOLD—CENSUS OF 1951 AND AGRICULTURAL LABOUR ENQUIRY—(*concluded*)

States and divisions	source	occupations									
		owners	tenants	non-cultivating holders	agricultural labour with land	all landholders	agricultural labour without land	all agricultural labourers	all agricultural occupations	other occupations	total population
Uttar Pradesh											
Kumaon-Garhwal	census	81.9	5.3	0.2	—	87.4	—	1.2	88.6	11.4	100.0
	ALE	45.4	43.8	—	—	89.2	—	—	89.2	10.8	100.0
East U.P.	census	73.4	6.9	0.5	—	81.1	—	6.8	87.9	12.1	100.0
	ALE	5.4	61.4	—	10.2	77.0	5.9	16.1	82.9	17.1	100.0
Oudh	census	72.7	6.4	1.3	—	80.4	—	5.7	86.1	13.9	100.0
	ALE	5.1	62.9	—	6.9	74.9	6.5	13.4	81.4	18.6	100.0
West U.P.	census	66.9	3.7	1.2	—	71.8	—	6.2	78.0	22.0	100.0
	ALE	12.6	52.8	—	3.3	68.7	9.8	13.1	78.5	21.5	100.0
South U.P.	census	62.7	8.0	1.3	—	72.0	—	12.9	84.9	15.1	100.0
	ALE	7.0	48.2	—	3.1	58.3	10.4	13.5	68.7	31.3	100.0
West Bengal											
Darjeeling-Duars	census	34.0	24.7	0.4	—	59.1	—	3.6	62.7	37.3	100.0
	ALE	29.8	36.7	—	22.6	89.1	9.2	31.8	98.2	1.7	100.0
W. Bengal Plain	census	43.3	14.8	0.6	—	58.7	—	17.3	76.0	24.0	100.0
	ALE	1.9	44.3	—	7.9	54.0	10.5	18.4	64.5	35.5	100.0
Sikkim	census	85.4	7.7	0.1	—	93.2	—	0.1	93.3	6.7	100.0
	ALE					no villages surveyed					

Source : Census—Census of India, 1951, Vol. I, Part II-C, *Economic Tables*, pp. 2, 6, 8, 10, 12, and 14.
Agricultural Labour Enquiry—Government of India—Ministry of Labour, *Rural Manpower and Occupational Structure* 1954. Table No. 3 for all States.

TABLE A.12. PROPORTION OF CULTIVATING CLASSES (FAMILIES) TO ALL CLASSES (FAMILIES), RURAL POPULATION, 75 DISTRICTS, CENSUS OF 1951, AND RURAL CREDIT SURVEY 1951-1952

States and divisions	districts	census	rural credit survey
		cultivating owners and tenants, and their dependents	cultivating families
Andhra			
Coastal Andhra	West Godavari	46.4	48.2
Telengana	Mahbubnagar	54.0	56.6
	Nizamabad	59.8	81.1
Rayalaseema	Cuddapah	55.3	78.3
	Kurnool	51.0	70.3
Assam			
Assam Valley	Cachar	59.3	72.5
	Kamrup	81.4	71.4
	Lakhimpur	56.7	66.2
Tripura	Tripura	72.8	72.9
Bihar			
North Bihar	Monghyr North	53.8	52.7
South Bihar	Bhagalpur	59.6	73.4
Chhota Nagpur	Hazaribagh	82.5	81.3
	Palamau	74.0	79.8
Gujarat			
Gujarat	Ahmedabad	52.0	54.1
	Broach	58.2	56.7
Saurashtra	Sorath	62.5	67.6
Kerala			
Travancore-Cochin	Quilon	41.7	69.7
Malabar	Malabar	29.2	83.3
Madhya Pradesh			
Malwa	Shivpur	73.6	83.6
	Shajapur	64.0	66.5
	Bhilsa	57.0	58.3
Dhar-Jhabua-Nimar	Jhabua	87.7	95.7
Bhopal	Raisen	50.2	57.5
Jabalpur-Sagar	Sagar	56.2	71.7
Chhattisgarh	Bilaspur	76.2	86.9
	Durg	65.4	82.1
Bundelkhand	Rewa	68.1	65.3
	Satna	67.0	75.4
Madras			
Tamilnad	Coimbatore	41.4	43.8
	Chingleput	49.5	63.9
	Ramnad	64.1	82.8
Maharashtra			
Konkan	Ratnagiri	70.1	75.9
Deccan	West Khandesh	65.7	60.5
	Poona	72.7	66.3
	Kolhapur	79.7	85.9

TABLE A.12. PRPPORTION OF CULTIVATING CLASSES (FAMILIES) TO ALL CLASSES (FAMILIES), RURAL POPULATION, 75 DISTRICTS, CENSUS OF 1951, AND RURAL CREDIT SURVEY 1951-1952—*(continued)*

States and divisions	districts	census	rural credit survey
		cultivating owners and tenants, and their dependents	cultivating families
Berar-Nagpur	Akola	43.3	46.3
	Nagpur	45.8	51.3
Chhattisgarh	Chanda	59.3	55.9
Marathwada	Parbhani	55.2	50.0
	Osmanabad	57.8	55.5
Mysore			
Mysore	Bangalore	70.6	78.7
	Hassan	82.8	76.7
North Karnatak	Bijapur	57.4	68.9
Orissa			
Coastal Orissa	Puri	66.6	62.0
Inland Orissa	Sambalpur	66.4	67.3
	Koraput	69.0	41.0
Punjab			
Punjab Plain	Hoshiarpur	63.8	56.5
	Jullunder	48.2	21.0
	Hissar	81.9	72.8
Patiala	Bhatinda	70.8	64.3
	Mohindergarh	82.9	88.7
Himachal	Sirmoor	91.7	83.5
Rajasthan			
Jaipur-Alwar	Jaipur	68.4	73.9
	Sawaimadhopur	77.6	85.1
Jodhpur-Bikaner	Churu	95.6	89.4
	Barmer	80.9	92.4
	Sirohi	50.0	69.2
Mewar	Chittorgarh	81.3	69.7
Kotah-Bundi			
Uttar Pradesh			
Kumaon-Garhwal	Nainital	76.6	47.3
East U.P.	Deoria	89.6	92.7
	Jaunpur	78.1	75.8
	Ballia	67.1	77.7
Oudh	Kanpur	74.7	75.1
	Sitapur	85.0	83.5
	Sultanpur	78.5	91.0
West U.P.	Meerut	52.6	60.7
	Aligarh	60.8	48.8
	Agra	69.2	74.4
	Shahjahanpur	84.5	86.3
South U.P.	Hamirpur	67.7	62.0
	Mirzapur	65.6	64.4

TABLE A.12. PROPORTION OF CULTIVATING CLASSES (FAMILIES) TO ALL CLASSES (FAMILIES), RURAL POPULATION, 75 DISTRICTS, CENSUS OF 1951, AND RURAL CREDIT SURVEY 1951-1952—(*concluded*)

States and divisions	districts	census	rural credit survey
		cultivating owners and tenants, and their dependents	cultivating families
West Bengal			
Darjeeling-Duars	Jalpaiguri	50.5	85.3
West Bengal Plain	Burdwan	52.8	56.2
	Midnapur	72.3	83.2
	Malda	60.8	50.3

Sources : Census of India, 1951, Vol. I, Part II-A, *Demographic Tables*, pp. 365-388.

All-India Rural Credit Survey : Vol. II, *The Technical Report*, 1956, pp. 240-241.

Note : The Rural Credit Survey figures for the percentages of cultivating families to all village families are derived from entries in the General Schedule, which was filled up for every family in eight sample villages for each of 75 selected districts.

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ESSAYS ON ECONOMETRICS AND PLANNING

Presented to Professor P. C. Mahalanobis on the occasion of his 70th birthday

Edited by

C. R. RAO

In Collaboration with

D. B. LAHIRI K. R. NAIR

P. PANT S. S. SHRIKHANDE

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A PROPERTY OF THE PARETO DISTRIBUTION

By N. BHATTACHARYA

Indian Statistical Institute

SUMMARY. Suppose we have an income distribution over the range x_0 to ∞ ($x_0 > 0$), and suppose we consider truncated forms of this distribution over (x_l, ∞) where $x_l \geqslant x_0$. It is proved that the concentration curve (and the concentration coefficient) for this truncated distribution will be independent of x_l if and only if the income distribution has the Pareto form.

Consider a Pareto distribution of income (x) over (x_0, ∞). (There may or may not be a part of the distribution below x_0 which does not follow the Pareto equation.) Then we have

$$N_x = Ax^{-\nu} \qquad \dots \quad (1)$$

where N_x is the number of persons having income $\geqslant x$, and A, ν are parameters. Since $N_{x_l} = Ax_l^{-\nu}$, we have the distribution function $F(x \,|\, x \geqslant x_l)$ of the truncated distribution

$$F(x \,|\, x \geqslant x_l) = 1 - \left(\frac{x}{x_l}\right)^{-\nu}. \qquad \dots \quad (2)$$

The concentration curve of this distribution is the same as that of $y = \frac{x}{x_l}$, since x_l is a constant for the time being. But the distribution function of y is given by

$$\begin{aligned} G(y \,|\, x \geqslant x_l) &= F(x_l y \,|\, x \geqslant x_l) \\ &= 1 - y^{-\nu} \; (y \geqslant 1). \qquad \dots \quad (3) \end{aligned}$$

Since this distribution is independent of x_l, the concentration curve for y and hence that of x is independent of x_l. This proves the first part of the theorem. It follows that the Gini concentration coefficient (also called the Lorenz ratio) is also independent of the point of truncation x_l.

As regards the converse, suppose $H(x)$ is the general form of the distribution function over (x_0, ∞) which possesses the above property. The d.f. of the truncated distribution over (x_l, ∞) with $x_l \geqslant x_0$ is given by

$$F(x \,|\, x \geqslant x_l) = \frac{H(x) - H(x_l)}{1 - H(x_l)}. \qquad \dots \quad (4)$$

Consider the variate $y = \frac{x}{x_l}$ again. The d.f. of y corresponding to $F(x|x \geqslant x_l)$ is

$$G(y|x \geqslant x_l) = \frac{H(x_l y)-H(x_l)}{1-H(x_l)} \text{ for all } y \geqslant 1. \qquad \ldots \quad (5)$$

Since the concentration curve for the truncated x-distribution is the same as the concentration curve for the corresponding distribution of $\frac{x}{x_l} = y$, and in virtue of the one-to-one relationship between the distribution function of y and its concentration curve,* our requirement becomes that $G(y|x \geqslant x_l)$ should be independent of x_l. Thus we get the condition that

$$\frac{H(xy)-H(x)}{1-H(x)} = G(y) \text{ independent of } x. \qquad \ldots \quad (6)$$

Here $1 \leqslant y \leqslant \infty$, and $x_0 \leqslant x < \infty$.

Assuming differentiability properties we get the frequency function of y as

$$\frac{\frac{\partial H(xy)}{\partial y}}{1-H(x)} = \frac{x\left.\frac{dH(z)}{dz}\right|_{z=xy}}{1-H(x)} = g(y), \text{ independent of } x. \qquad \ldots \quad (7)$$

Now it appears that the condition that $g(1)$ is independent of x ensures that $H(x)$ is of the Pareto form. For let $y \rightarrow 1$ from above in (7). We get

$$\frac{\frac{xdH(x)}{dx}}{1-H(x)} = g(1) = c \text{ say } (c > 0). \qquad \ldots \quad (8)$$

The differential equation

$$\frac{dH(x)}{dx} + \frac{c}{x} H(x) = \frac{c}{x} \qquad \ldots \quad (9)$$

is one of a standard form, and the general solution is

$$1-H(x) = ax^{-c} \text{ (where } a > 0) \qquad \ldots \quad (10)$$

which is of the Pareto form.

It has already been seen that for the Pareto distribution $g(y|x \geqslant x_l)$ is independent of x_l for all $y \geqslant 1$.

Observations. Income distributions emanating from income-tax statistics are generally of the truncated form (ignoring some complications), but concentration curves based on them are quite often used in inequality studies. If the entire distribution is of the Pareto form, the truncated distribution can be safely used for inferences about the inequality of the entire distribution. But since the Pareto curve rarely fits over the whole range, one should be careful to distinguish between concentration curves based on truncated distributions from those based on complete ones. [It would be interesting to investigate the effect of truncation on the concentration curve, for instance, when the complete distribution is lognormal.] What is more important is that when truncated distributions of different years are compared for inequality, the points of truncation should be made equal in the real income sense, because differences in the point of truncation may lead to fictitious differences in inequality.

Paper received : February, 1963.

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* This is due to the fact that whatever be x_l, the distribution of y starts from the value 1.

HYPERGEOMETRIC FUNCTION

By P. C. CONSUL

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SUMMARY. The paper gives an explicit account of a systematic method of tabulating the values of hypergeometric function $F(a, b; c; x)$ for values of a, b, c and x and provides the formulae for testing their accuracy and for interpolating the function for intermediate values of a, b, c and x. The author has tabulated the values of the function upto seven significant figures over a range $a=\frac{1}{2}$, 1, 1.5, 2.3, ..., 30; $b=c-1$, c, $c+1$; $c=1, 2, 3$; and $x=.01, .02, \ldots, .09, .1, .2, .3, \ldots, .9, .95$.

1. INTRODUCTION

The hypergeometric function $F(a, b; c; x)$ is defined by the series

$$F(a, b; c; x) = 1+\frac{ab}{c.1}\times x+\frac{a(a+1).b(b+1)}{c(c+1).1.2}\times x^2+\ldots \qquad \ldots \quad (1.1)$$

which is absolutely and uniformly convergent if $|x| < 1$, divergent when $|x| > 1$, and is absolutely convergent when $|x| = 1$ if $R(c-a-b) > 0$. Macrobert (1954), Whittaker (1927), and Watson (1918), have discussed the analytical properties of this function which satisfies the differential equation

$$x(1-x)\times\frac{d^2F}{dx^2}+\{c-(a+b+1)x\}\frac{dF}{dx}-ab\times F = 0. \qquad \ldots \quad (1.2)$$

Many other differential equations constituting an important class in themselves are soluble by means of the hypergeometric function F, and have been discussed by Bailey (1935). The solution of many problems of engineering and physics depend upon such differential equations.

Numerous attempts have, so far, been made to tabulate the values of this function and a few scattered values exist but it appears that no elaborate method is available as yet. We have given a systematic method, based on a number of recurrence relations, for the tabulation of the values of the hypergeometric function. The method is very simple though quite laborious. The method has been utilised to tabulate the values of the function upto seven significant figures over a range $a = \frac{1}{2}$, 1, $\frac{3}{2}$, 2, 3, 4,..., 30; $b = c-1$, c, $c+1$; $c = 1, 2, 3$; and $x = .01, .02, .03, \ldots, .09, .1, .2, \ldots, .9, .95$. We have given methods for the extension of these tables to a larger range. A method has also been given by which the accuracy of the tables can be easily tested. Attempts have also been made to indicate the interpolation formulae, for the different tables, which enable us to obtain the values of the function for intermediate values of a, b, c, and x.

2. IMPORTANCE IN STATISTICS

The hypergeometric function is of very great practical importance to a statistician, an applied mathematician and an engineer. The importance of this function in statistics was first illustrated by Pearson (1895, 1924), Camp (1925), and Romanovsky (1925) when they obtained the hypergeometric distribution and its different moments. Pearson (1924) also proved that the moments of the distribution of covariance in a normal case are obtained as infinite series which are expressible in terms of hypergeometric functions. Later, Wishart (1929) established that the evaluation of the variance of a bivariate normal population depends upon the values of this function.

While considering the general sampling distribution of multiple correlation coefficient, Fisher (1928) obtained the complicated distribution in the hypergeometric form. He considered its particular cases but they were also of the same form. He also proved that even the moments and the probability integrals of the distribution were in terms of hypergeometric functions.

Rao (1949) has shown that the exact distribution of $D^2_{p+q}-D^2_p$, the differences between two D^2's based on $(p+q)$ and p characters, is in the form of a hypergeometric series. Since the tabulated values of the function did not exist, he obtained, subsequently, a number of approximations to the exact distribution.

3. Construction of the tables

The following tables given in the Appendix have been computed for

$b = c;$ $\quad a = \frac{1}{2}, 1, \frac{3}{2}, 2, 3, 4, \ldots, 30$

$b = 2;\ c = 1;$ $\quad a = \frac{1}{2}, 1, \frac{3}{2}, 2, 3, 4, \ldots, 30$

$b = 3;\ c = 2;$ $\quad a = \frac{1}{2}, 1, \frac{3}{2}, 2, 3, 4, \ldots, 30$

$b = 4;\ c = 3;$ $\quad a = \frac{1}{2}, 1, \frac{3}{2}, 2, 3, 4, \ldots, 30$

$b = 3;\ c = 1;$ $\quad a = \frac{1}{2}, 1, 2, 3, 4, \ldots, 29$

$b = 1;\ c = 2;$ $\quad a = 1, 1.5, 2, 3, 4, \ldots, 30$

and $\quad x = .01, .02, .03, \ldots, .09, .1, .2, .3, \ldots, .9, .95.$

The values of the function have been given to seven significant figures. The tabular values when multiplied by the power of ten shown in small figures on the left, give the correct values of the function upto seven significant figures. Thus

$$F(20,\ c;\ c;\ \ 0.4) = 10^4 \times 2.735111 = 27351.11$$
$$F(15,\ 2;\ 1;\ \ 0.6) = 10^7 \times 2.188608 = 21886080$$
$$F(26,\ 3;\ 1;\ \ .07) = 10 \times 4.554616 = 45.54616$$
$$F(24,\ 3;\ 2;\ \ 0.95) = 10^{33} \times 3.841982 = 3841982\times 10^{27}$$
$$F(30,\ 1;\ 2;\ \ 0.8) = 10^{18} \times 8.028642 = 8028642\times 10^{12}.$$

The actual computations of the tables, for successive values of a and x, were carried out in three parts as given below

(I) when $b = c$; c having all possible values,

(II) when $b = c+1,\ c+2$; for particular values of c,

(III) when $c = b+1$; for particular values of b.

Case (I) : *When* $b = c$. The function $F(a, c; c; x) = (1-x)^{-a}$ so that for any given value of x such that $-1 < x < +1$, the values of $F(\frac{1}{2}, c; c; x) = (1-x)^{-\frac{1}{2}}$ and $F(1, c; c; x) = (1-x)^{-1}$ were obtained directly from Barlow's Tables upto 9 significant figures. To obtain any one column, the corresponding value of $(1-x)^{-1}$ was taken in the setting register of a calculating machine. It was then multiplied with the corresponding value of $(1-x)^{-1/2}$ which gave $(1-x)^{-3/2}$ as a product.. Then without altering the setting register, the successive products were taken with $(1-x)^{-1}$, $(1-x)^{-2}$, $(1-x)^{-3}$, ... etc., which were being obtained as the products in the product-register. Thus the values of the function for each column were obtained for successive values of a increasing by unity. The procedure was repeated mechanically for different values of x.

Case (II) : (i) *When* $b = c+1$. For each particular value of c, the recurrence relation

$$c.F(a, c+1; c; x) = a.F(a+1, c; c; x)+(c-a)\,F(a, c; c; x) \qquad \ldots \quad (3.1)$$

was used successively to obtain the different values of the function $F(a, 2; 1; x)$ and $F(a, 3; 2; x)$ for each value of a and x. Having already obtained the functional values for $b = c$, these computations were performed columnwise by the aid of a calculating machine without much difficulty. The division by the value of c was carried out orally.

(ii) *When* $b = c+2$. For each particular value of c, the recurrence relation

$$(c+1),\ F(a, c+2; c; x) = a \,.\, F(a+1, c+1; c; x)+(c-a+1)\,.\,F(a, c+1; c; x) \ \ldots \quad (3.2)$$

which is only a slight modification of (3.1), was used successively to obtain the values of $F(a, 3; 1; x)$ for different values of a and x. The method adopted for computation was similar to that followed in (i) above.

Case (III) : *When* $c = b+1$. For different values of b, $(= 1, 2, 3,\ldots)$ the recurrence relation

$$F(a+1; b; b+1; x) = \frac{b}{ax}\,[F(a, b; b; x)-F(a, b-1; b; x)] \qquad \ldots \quad (3.3)$$

was used successively. The values of the function $F(a, 1; 1; x)$ were taken from Table 1 and $F(a, 0; 1; x) = 1$. These values enabled us to obtain the values of the function $F(a+1, 1; 2; x)$ for successive values of a and x.

4. Further extension of the tables

An immediate extension of the tables, given here, in Cases (II) (i) and II(ii) for other values of c and for the same values of a and x, can be done without much labour by repeated use of the recurrence relations (3.1) and (3.2). The method has already been explained above.

However, if tables are required for higher values of b and lower values of c, those relations will not be useful, but the following general recurrence formula will enable us to tabulate the values of the function

$$F(a, b+1; c; x) = \frac{1}{b}[a.F(a+1, b; c; x)+(b-a)F.(a, b; c; x). \qquad \ldots \quad (4.1)$$

The relations (3.1) and (3.2) are only particular cases of the above.

Similarly, in Case (III) tables have been given for $b = 1$ only. They can be easily extended further for different values of b, by the repeated use of the same recurrence relation (3.3). However, if tables are required for higher values of c and lower values of b, then the following recurrence relation will be found useful

$$F(a+1, b; c+1; x) = \frac{c}{ax}[F(a, b; c; x)-F(a, b-1; c; x)]. \qquad \ldots \quad (4.2)$$

It may be mentioned here that while making this extension, it must be kept in mind that the repeated use of the recurrence relations, for higher values of b and c, would entail a rapid loss of accuracy. But, for values of b and c less than ten, the functional values obtained by this method of extension would be reliable at least upto five significant figures provided nine significant figures are used in the extension of the tables.

In statistics, usually, we come across the hypergeometric functions for positive values of x only. So the tables for the negative values of x need not be computed. However, if need is felt, they will have to be computed exactly on the same lines as for the positive values of x. Separate tables for the negative values of a and b are not needed as we have the relations

$$F(a, b; c; x) = (1-x)^{-a}. F\left(a, c-b; c; \frac{x}{x-1}\right) \qquad \ldots \quad (4.3)$$

$$= (1-x)^{-b}. F\left(b, c-a; c; \frac{x}{x-1}\right) \qquad \ldots \quad (4.4)$$

$$= (1-x)^{c-a-b}. F(c-a, c-b; c; x) \qquad \ldots \quad (4.5)$$

which enable us to convert the functions into those, which have the positive arguments.

5. INTERPOLATION BETWEEN THE VALUES

Since there are four variables in the function, it had to be tabulated under three different classes, for integral values of a, b, and c. But many times the values of the function are needed for values of these variables such as $\frac{3}{2}, \frac{5}{2}, \frac{7}{2}, \ldots$. For this, a number of interpolation formulae, for the different variables and cases, were tried and the following three methods were found to be well suited for the purpose.

When $b = c$, the geometric mean between the values of the function, for two successive values of a, gives an estimate of the functional value, correct upto six significant figures, for the correspondng mid-value of a.

When $b \neq c$, let $U_{a,b,c}$ denote the functional values for particular values of x. The estimates for the mid-values of a can be obtained from the formula

$$U_{a+\frac{1}{2},b,c} = \frac{1}{2}(U_{a,b,c}+U_{a+1,b,c})-\frac{1}{16}(\Delta^2 U_{a,b,c}+\Delta^2 U_{a+1,b,c}) \qquad \ldots \quad (5.1)$$

which gives an accuracy upto five significant figures. A similar formula obtained by interchanging a and b, can be used to estimate the functional values, for mid-values of b.

However, the following simpler formula was found to be useful for interpolating the functional values, for mid-values of c, giving accuracy upto five significant figures.

$$U_{a,b,c+\frac{1}{2}} = U_{a,b,c}+\frac{1}{2}\Delta U_{a,b,c}-\frac{1}{8}\Delta^2 U_{a,b,c}. \qquad \ldots \quad (5.2)$$

For intermediate values of x, Newton's advancing difference formula, upto second differences, can be used.

6. ACCURACY OF THE TABLES

After the calculation of each column the accuracy of the values was tested by evaluating the values of the function directly from the series. For actual computation of the values, we expressed each term of the series in terms of the preceeding one as shown below. Thus

$$\begin{aligned} F(a, b; c; x) &= 1+\frac{a.b}{c.1}x+\frac{a(a+1).b(b+1)}{c(c+1)1.2}x^2+\ldots \\ &= 1+U_1+U_2+U_3+\ldots \\ &= 1+U_1+U_1.\frac{(a+1)(b+1)}{(c+1)}\frac{x}{2}+U_2.\frac{(a+2)(b+2)}{(c+2)}.\frac{x}{3}+\ldots \qquad \ldots \quad (6.1) \end{aligned}$$

so that after obtaining the value of U_1, we could get the following terms by merely multiplying the successive terms by factors whose values could be easily written down, e.g.

$$F(20, 3; 2; x) = 1+30x+U_1.14x+U_2.\frac{55}{6}x+\ldots$$

and

$$F(10, 1; 2; x) = 1+5x+U_1.\frac{11}{3}x+U_2.3x+\ldots.$$

It may be noted here that, for fixed values of a, b, and c, these coefficients of U's do not change. Even when the value of a changes, they change only slightly.

In the computation of these tables throughout we have worked with nine significant figures. Since the repeated use of the recurrence relations did not produce any discrepancy beyond the last two figures, we have given tables upto seven significant figures, which may, therefore, be taken to be correct.

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Appendix

TABLE 1. VALUES OF $F(a, c; c; x)$

a \ x	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.5	1.005038	1.010153	1.015346	1.020621	1.025978	1.031421	1.036952	1.042572	1.048285
1.5	1.015190	1.030768	1.046749	1.063147	1.079977	1.097257	1.115002	1.133231	1.151961
2.5	1.025444	1.051804	1.079122	1.107444	1.136818	1.167294	1.198927	1.231772	1.265892
1	1.010101	1.020408	1.030928	1.041667	1.052632	1.063830	1.075269	1.086957	1.098901
2	1.020304	1.041233	1.062812	1.085069	1.108033	1.131734	1.156203	1.181474	1.207854
3	1.030610	1.062482	1.095683	1.130281	1.166351	1.203972	1.243229	1.284211	1.327015
4	1.041020	1.084166	1.129570	1.177396	1.227738	1.280821	1.336805	1.395882	1.458258
5	1.051536	1.106292	1.164505	1.226433	1.292355	1.362567	1.437425	1.517263	1.602482
6	1.062157	1.128869	1.200521	1.277534	1.360374	1.449549	1.545619	1.649199	1.760969
7	1.072886	1.151907	1.237650	1.330765	1.431973	1.542073	1.661955	1.792607	1.935130
8	1.083723	1.175415	1.275938	1.386214	1.507340	1.640503	1.787049	1.948486	2.126517
9	1.094670	1.199404	1.315390	1.443972	1.586673	1.745217	1.921558	2.117920	2.336832
10	1.105727	1.223881	1.356072	1.504138	1.670183	1.856613	2.066191	2.302087	2.567947
11	1.116896	1.248858	1.398012	1.566810	1.758087	1.975121	2.221711	2.502268	2.821920
12	1.128178	1.274345	1.441250	1.632094	1.850618	2.101192	2.388937	2.719856	3.101011
13	1.139574	1.300352	1.485824	1.700098	1.948019	2.235311	2.568749	2.956366	3.407704
14	1.151085	1.326890	1.531778	1.770935	2.050546	2.377990	2.762096	3.213442	3.744730
15	1.162712	1.353969	1.579152	1.844724	2.158470	2.529777	2.969995	3.492871	4.115088
16	1.174456	1.381601	1.627992	1.921588	2.272073	2.691252	3.193543	3.796599	4.522075
17	1.186320	1.409797	1.678342	2.001654	2.391656	2.863034	3.433918	4.126738	4.969131
18	1.198303	1.438569	1.730250	2.085056	2.517533	3.045781	3.692385	4.485585	5.460783
19	1.210407	1.467927	1.783763	2.171934	2.650034	3.240192	3.970306	4.875636	6.000861
20	1.222633	1.497885	1.838930	2.262431	2.789510	3.447013	4.269146	5.299604	6.594353
21	1.234983	1.528454	1.895805	2.356699	2.936326	3.667035	4.590480	5.760439	7.246541
22	1.247457	1.559647	1.954438	2.454895	3.090870	3.901101	4.936000	6.261347	7.963232
23	1.260058	1.591477	2.014884	2.557182	3.253547	4.150108	5.307527	6.805812	8.750805
24	1.272786	1.623956	2.077200	2.663731	3.424786	4.415008	5.707018	7.397622	9.616269
25	1.285642	1.657098	2.141444	2.774720	3.605038	4.696817	6.136579	8.040893	11.056733
26	1.298628	1.690916	2.207674	2.890333	3.794777	4.996614	6.598472	8.740101	11.161245
27	1.311746	1.725424	2.275952	3.010764	3.994502	5.315547	7.095131	9.500110	11.276093
28	1.324996	1.760637	2.346343	3.136212	4.204739	5.654837	7.629173	11.032621	11.402300
29	1.338380	1.796569	2.418910	3.266888	4.426041	6.015784	8.203412	11.122425	11.540989
30	1.351899	1.833233	2.493722	3.403008	4.658991	6.399771	8.820873	11.220027	11.693395

TABLE 1. VALUES OF $F(a, c ; c ; x)$ (*Contd.*)

a \ x	.1	.2	.3	.4	.5	.6	.7	.8	.9	.95
0.5	1.054093	1.118034	1.195229	1.290994	1.414214	1.481139	1.825742	2.236068	3.162278	4.472136
1.5	1.171214	1.397542	1.707469	2.151657	2.828427	3.952847	6.085806	11.118034	13.162278	18.944272
2.5	1.301349	1.746928	2.439242	3.586096	5.656854	9.882118	12.028602	15.590170	13.162278	31.788854
1	1.111111	1.250000	1.428571	1.666667	2.000000	2.500000	3.333333	5.000000	11.000000	12.000000
2	1.234568	1.562500	2.040816	2.777778	4.000000	6.250000	11.111111	12.500000	21.000000	24.000000
3	1.371742	1.953125	2.915452	4.629630	8.000000	11.562500	13.703704	21.250000	31.000000	38.000000
4	1.524158	2.441406	4.164931	7.716049	11.600000	13.906250	21.234568	26.250000	41.000000	51.600000
5	1.693509	3.051758	5.949902	11.286008	13.200000	19.765625	24.115226	33.125000	51.000000	63.200000
6	1.881676	3.814697	8.499860	12.143347	16.400000	22.441406	31.371742	41.562500	61.000000	76.400000
7	2.090752	4.768372	11.214266	13.572245	21.280000	26.103516	34.572474	47.812500	71.000000	91.280000
8	2.323057	5.960464	11.734665	15.953742	22.560000	31.525879	41.534158	53.906250	81.000000	102.560000
9	2.581175	7.450581	12.478093	19.922903	25.120000	33.814697	45.080526	61.953135	91.000000	115.120000
10	2.867792	9.313226	13.540133	21.653817	31.024000	39.536743	51.693509	69.765625	101.000000	131.024000
11	3.186636	11.164153	15.057333	22.756362	32.048000	42.384186	55.645029	74.882812	111.000000	142.048000
12	3.540706	11.455192	17.224762	24.593937	34.096000	45.960464	61.881676	82.441406	121.000000	154.096000
13	3.934118	11.818989	21.032109	27.656561	38.192000	51.490116	66.272255	91.220703	131.000000	168.192000
14	4.371242	12.273737	21.474441	31.276094	41.638400	53.725290	72.090752	96.103516	141.000000	181.638400
15	4.856936	12.842171	22.106344	32.126822	43.276800	59.313226	76.969172	103.051758	151.000000	193.276800
16	5.396595	13.552714	23.009064	33.544704	46.553600	62.328206	82.323057	111.525879	161.000000	206.553600
17	5.996622	14.440892	24.298662	35.907843	51.310720	65.830766	87.743524	117.629395	171.000000	221.310720
18	6.662463	15.551115	26.140946	39.846401	52.621440	71.455192	92.581175	123.814697	181.000000	232.621440
19	7.402737	16.938894	28.772780	41.641067	55.242880	73.637979	98.603916	131.907349	191.000000	245.242880
20	8.225263	18.673617	31.253254	42.735111	61.048567	79.094947	102.867972	139.536743	201.000000	261.048576
21	9.139181	21.084202	31.790363	44.558519	62.097152	82.273737	109.559907	144.768372	211.000000	272.097152
22	11.015465	21.355253	32.557662	47.597533	64.194304	85.684342	113.186636	152.384186	221.000000	284.194304
23	11.128294	21.694066	33.653803	51.266256	68.388608	91.421085	121.062212	161.192093	231.000000	298.388608
24	11.253660	22.117582	35.219718	52.110425	71.677722	93.552714	123.540706	165.960464	241.000000	311.677772
25	11.392956	22.646978	37.456740	53.517376	73.355443	98.881784	131.180325	172.980232	251.000000	323.355443
26	11.547728	23.308722	41.065248	55.862293	76.710886	102.220446	133.934118	181.490116	261.000000	336.710886
27	11.719698	24.135903	41.521783	59.770488	81.342177	105.551115	141.311373	187.450581	271.000000	351.342177
28	11.910776	25.169879	42.173977	61.628415	82.684355	111.387779	144.371242	193.725290	281.000000	362.684354
29	12.123084	26.462348	43.105681	62.714024	85.368709	113.469447	151.457081	201.862645	291.000000	375.368709
30	12.358982	28.077936	44.436687	64.523374	91.073742	118.673617	154.856936	209.313225	301.000000	391.073742

TABLE 2. VALUES OF $F(a, 2; 1; x)$

$a \backslash x$	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.5	1.010114	1.020460	1.031047	1.041884	1.052978	1.064339	1.075977	1.087901	1.100123
1.5	1.030571	1.062322	1.095309	1.129593	1.165239	1.202313	1.240889	1.281043	1.322857
1	1.020304	1.041233	1.062812	1.085069	1.108033	1.132734	1.156203	1.181474	1.207584
2	1.040916	1.083732	1.128553	1.175492	1.224668	1.276210	1.330255	1.386948	1.446446
3	1.061841	1.127532	1.197344	1.271566	1.350511	1.434520	1.523958	1.619223	1.720745
4	1.083082	1.172669	1.269310	1.373605	1.486209	1.607840	1.739284	1.881406	2.035152
5	1.104644	1.219179	1.344583	1.481940	1.632449	1.797441	1.978392	2.176943	2.394918
6	1.126530	1.267098	1.423298	1.596918	1.789966	2.004695	2.243640	2.509650	2.805939
7	1.148747	1.316466	1.505595	1.718905	1.959542	2.231085	2.537609	2.883760	3.274836
8	1.171297	1.367320	1.591621	1.848285	2.142009	2.478208	2.863121	3.303955	3.809036
9	1.194186	1.419702	1.681529	1.985462	2.338256	2.747788	3.223258	3.775423	4.416869
10	1.217417	1.473653	1.775475	2.130862	2.549226	3.041686	3.621389	4.303902	5.107675
11	1.240996	1.529214	1.873624	2.284932	2.775927	3.361907	4.061192	4.895742	5.891921
12	1.264927	1.586430	1.976146	2.448141	3.019429	3.710616	4.546686	5.557968	6.781332
13	1.289215	1.645344	2.083218	2.620984	3.280874	4.090143	5.082256	6.298345	7.789038
14	1.313864	1.706001	2.195021	2.803981	3.561475	4.503003	5.672691	7.125457	8.929741
15	1.338880	1.768450	2.311749	2.997677	3.862524	4.951904	6.323216	8.048790	$^{1}1.021989$
16	1.364267	1.832737	2.433596	3.202646	4.185398	5.439765	7.039531	9.078824	$^{1}1.167789$
17	1.390031	1.898911	2.560769	3.419492	4.531569	5.969730	7.827856	$^{1}1.022713$	$^{1}1.332431$
18	1.416176	1.967023	2.693481	3.648849	4.902564	6.545189	8.694970	$^{1}1.150650$	$^{1}1.518218$
19	1.442707	2.037124	2.831953	3.891381	5.300069	7.169788	9.648271	$^{1}1.293103$	$^{1}1.727720$
20	1.469630	2.109267	2.976413	4.147790	5.725836	7.847456	$^{1}1.069582$	$^{1}1.451631$	$^{1}1.963813$
21	1.496949	2.183506	3.127100	4.418810	6.181739	8.582423	$^{1}1.184640$	$^{1}1.627950$	$^{1}2.229705$
22	1.524670	2.259897	3.284261	4.705215	6.669771	9.379244	$^{1}1.310959$	$^{1}1.823958$	$^{1}2.528983$
23	1.552799	2.338496	3.448152	5.007815	7.192057	$^{1}1.024282$	$^{1}1.449583$	$^{1}2.041744$	$^{1}2.865648$
24	1.581340	2.419362	3.619039	5.327462	7.750832	$^{1}1.117843$	$^{1}1.601649$	$^{1}2.283614$	$^{1}3.244170$
25	1.610299	2.202556	3.797199	5.665053	8.348510	$^{1}1.219174$	$^{1}1.768390$	$^{1}2.552110$	$^{1}3.669534$
26	1.639682	2.588137	3.982917	6.021528	8.987630	$^{1}1.328887$	$^{1}1.951161$	$^{1}2.850033$	$^{1}4.147303$
27	1.669495	2.676168	4.176490	6.397873	9.670900	$^{1}1.447638$	$^{1}2.151427$	$^{1}3.180741$	$^{1}4.683683$
28	1.699742	2.766716	4.378227	6.795127	$^{1}1.040120$	$^{1}1.576136$	$^{1}2.370786$	$^{1}3.547132$	$^{1}5.285593$
29	1.730430	2.859844	4.588448	7.214377	$^{1}1.118158$	$^{1}1.715139$	$^{1}2.610978$	$^{1}3.952887$	$^{1}5.960750$
30	1.761565	2.955621	4.807484	7.656769	$^{1}1.201529$	$^{1}1.865465$	$^{1}2.873897$	$^{1}4.402705$	$^{1}6.717753$

TABLE 2. VALUES OF $F(a, 2 ; 1 ; x)$ (*Contd.*)

a \ x	.1	.2	.3	.4	.5	.6	.7	.8	.9	.95
0.5	1.112653	1.257788	1.451349	1.721326	2.121320	2.766993	3.955774	6.708204	${}^{1}1.739253$	${}^{1}4.695743$
1.5	1.366416	1.921621	2.805128	4.303315	7.071068	${}^{1}1.284675$	${}^{1}2.738613$	${}^{1}7.826238$	${}^{2}4.585303$	${}^{3}2.638560$
1	1.234568	1.562500	2.040816	2.777778	4.000000	6.250000	${}^{1}1.111111$	${}^{1}2.500000$	${}^{2}1.000000$	${}^{2}4.000000$
2	1.508916	2.343750	3.790087	6.481481	${}^{1}1.200000$	${}^{1}2.500000$	${}^{1}6.296296$	${}^{2}2.250000$	${}^{3}1.900000$	${}^{4}1.560000$
3	1.828989	3.417969	6.663890	${}^{1}1.388889$	${}^{1}3.200000$	${}^{1}8.593750$	${}^{2}2.962963$	${}^{3}1.625000$	${}^{4}2.800000$	${}^{5}4.640000$
4	2.201561	4.882812	${}^{1}1.130481$	${}^{1}2.829218$	${}^{1}8.000000$	${}^{2}2.734375$	${}^{3}1.275720$	${}^{4}1.062500$	${}^{5}3.700000$	${}^{7}1.232000$
5	2.634347	6.866455	${}^{1}1.869969$	${}^{1}5.572702$	${}^{2}1.920000$	${}^{2}8.300781$	${}^{3}5.212620$	${}^{4}6.562500$	${}^{6}4.600000$	${}^{8}3.077200$
6	3.136127	9.536743	${}^{1}3.035664$	${}^{2}1.071674$	${}^{2}4.480000$	${}^{3}2.441406$	${}^{4}2.057613$	${}^{5}3.906250$	${}^{7}5.500000$	${}^{9}7.360000$
7	3.716892	${}^{1}1.311902$	${}^{1}4.857063$	${}^{2}2.024272$	${}^{3}1.024000$	${}^{3}7.019043$	${}^{4}7.925621$	${}^{6}2.265625$	${}^{8}6.400000$	${}^{11}1.715200$
8	4.387997	${}^{1}1.788129$	${}^{1}7.682089$	${}^{2}3.770703$	${}^{3}2.304000$	${}^{4}1.983643$	${}^{5}2.997511$	${}^{7}1.289062$	${}^{9}7.300000$	${}^{12}3.916800$
9	5.162350	${}^{1}2.421439$	${}^{2}1.203645$	${}^{2}6.946032$	${}^{3}5.120000$	${}^{4}5.531311$	${}^{6}1.117716$	${}^{7}7.226562$	${}^{10}8.200000$	${}^{13}8.806400$
10	6.054607	${}^{1}3.259629$	${}^{2}1.871213$	${}^{3}1.267927$	${}^{4}1.126400$	${}^{5}1.525879$	${}^{6}4.120871$	${}^{8}4.003906$	${}^{11}9.100000$	${}^{15}1.955840$
11	7.081412	${}^{1}4.365575$	${}^{2}2.889905$	${}^{3}2.296968$	${}^{4}2.457600$	${}^{5}4.172325$	${}^{7}1.505341$	${}^{9}2.197266$	${}^{13}1.000000$	${}^{16}4.300800$
12	8.261648	${}^{1}5.820766$	${}^{2}4.438068$	${}^{3}4.134543$	${}^{4}5.324800$	${}^{6}1.132488$	${}^{7}5.456862$	${}^{10}1.196289$	${}^{14}1.090000$	${}^{17}9.379840$
13	9.616733	${}^{1}7.730705$	${}^{2}6.782429$	${}^{3}7.421342$	${}^{5}1.146880$	${}^{6}3.054738$	${}^{8}1.965307$	${}^{10}6.469727$	${}^{15}1.180000$	${}^{19}2.031616$
14	${}^{1}1.117095$	${}^{2}1.023182$	${}^{3}1.032109$	${}^{4}1.318630$	${}^{5}2.457600$	${}^{6}8.195639$	${}^{8}7.038864$	${}^{11}3.479004$	${}^{16}1.270000$	${}^{20}4.374528$
15	${}^{1}1.295183$	${}^{2}1.350031$	${}^{3}1.564713$	${}^{4}2.339505$	${}^{5}5.242880$	${}^{7}2.188608$	${}^{9}2.508902$	${}^{12}1.861572$	${}^{17}1.360000$	${}^{21}9.371648$
16	${}^{1}1.499054$	${}^{2}1.776357$	${}^{3}2.364264$	${}^{4}4.135488$	${}^{6}1.114112$	${}^{7}5.820766$	${}^{9}8.905053$	${}^{12}9.918213$	${}^{18}1.450000$	${}^{23}1.998848$
17	${}^{1}1.732242$	${}^{2}2.331468$	${}^{3}3.561749$	${}^{4}7.286336$	${}^{6}2.359296$	${}^{8}1.542503$	${}^{10}3.149033$	${}^{13}5.264282$	${}^{19}1.540000$	${}^{24}4.246733$
18	${}^{1}1.998739$	${}^{2}3.053113$	${}^{3}5.351396$	${}^{5}1.280032$	${}^{6}4.980736$	${}^{8}4.074536$	${}^{11}1.109905$	${}^{14}2.784729$	${}^{20}1.630000$	${}^{25}8.991534$
19	${}^{1}2.303074$	${}^{2}3.989864$	${}^{3}8.020828$	${}^{5}2.242791$	${}^{7}1.048567$	${}^{9}1.073204$	${}^{11}3.900442$	${}^{15}1.468658$	${}^{21}1.720000$	${}^{27}1.897923$
20	${}^{1}2.650363$	${}^{2}5.204171$	${}^{4}1.199543$	${}^{5}3.920326$	${}^{7}2.202010$	${}^{9}2.819434$	${}^{12}1.367067$	${}^{15}7.724762$	${}^{22}1.810000$	${}^{28}3.995075$
21	${}^{1}3.046394$	${}^{2}6.776246$	${}^{4}1.790363$	${}^{5}6.837778$	${}^{7}4.613734$	${}^{9}7.389644$	${}^{12}4.779953$	${}^{16}4.053116$	${}^{23}1.900000$	${}^{29}8.388608$
22	${}^{1}3.497711$	${}^{2}8.809143$	${}^{4}2.667276$	${}^{6}1.190280$	${}^{7}9.646899$	${}^{10}1.932676$	${}^{13}1.667673$	${}^{17}2.121925$	${}^{24}1.990000$	${}^{31}1.757413$
23	${}^{1}4.011712$	${}^{3}1.143494$	${}^{4}3.966986$	${}^{6}2.068217$	${}^{8}2.013266$	${}^{10}5.044853$	${}^{13}5.806758$	${}^{18}1.108646$	${}^{25}2.080000$	${}^{32}3.674210$
24	${}^{1}4.596753$	${}^{3}1.482308$	${}^{4}5.890825$	${}^{6}3.587723$	${}^{8}4.194304$	${}^{11}1.314504$	${}^{14}2.018203$	${}^{18}5.781651$	${}^{26}2.170000$	${}^{33}7.667188$
25	${}^{1}5.262277$	${}^{3}1.919059$	${}^{4}8.735038$	${}^{6}6.214030$	${}^{8}8.724152$	${}^{11}3.419487$	${}^{14}7.002730$	${}^{19}3.010035$	${}^{27}2.260000$	${}^{35}1.587191$
26	${}^{1}6.018944$	${}^{3}2.481542$	${}^{5}1.293516$	${}^{7}1.074754$	${}^{9}1.811939$	${}^{11}8.881784$	${}^{15}2.426039$	${}^{20}1.564622$	${}^{28}2.350000$	${}^{36}3.321889$
27	${}^{1}6.878793$	${}^{3}3.205325$	${}^{5}1.913099$	${}^{7}1.856393$	${}^{9}3.758096$	${}^{12}2.303713$	${}^{15}8.392785$	${}^{20}8.121133$	${}^{29}2.440000$	${}^{37}6.898791$
28	${}^{1}7.855412$	${}^{3}4.135903$	${}^{5}2.826170$	${}^{7}3.202549$	${}^{9}7.784628$	${}^{12}5.967449$	${}^{16}2.899591$	${}^{21}4.209578$	${}^{30}2.530000$	${}^{39}1.430761$
29	${}^{1}8.964133$	${}^{3}5.331438$	${}^{5}4.170486$	${}^{7}5.518516$	${}^{10}1.610613$	${}^{13}1.543904$	${}^{17}1.000529$	${}^{22}2.179295$	${}^{31}2.620000$	${}^{40}2.963527$
30	${}^{2}1.022226$	${}^{3}6.866245$	${}^{5}6.477981$	${}^{7}9.499086$	${}^{10}3.328600$	${}^{13}3.989864$	${}^{17}3.449424$	${}^{23}1.126900$	${}^{32}2.710000$	${}^{41}6.131066$

TABLE 3. VALUES OF $F(a, 3; 2; x)$

a / x	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.5	1.007567	1.015307	1.023197	1.031252	1.039478	1.047880	1.056465	1.065237	1.074204
1.5	1.022881	1.046546	1.071029	1.096370	1.122608	1.149686	1.177947	1.207137	1.237409
1	1.015203	1.030820	1.046870	1.063369	1.080332	1.097782	1.115736	1.134215	1.153242
2	1.030610	1.062482	1.095683	1.130281	1.166351	1.203972	1.243229	1.284211	1.327015
3	1.046225	1.095007	1.146513	1.200923	1.258431	1.319246	1.383594	1.451717	1.523880
4	1.062051	1.128417	1.199440	1.275492	1.356973	1.444331	1.538045	1.638644	1.746705
5	1.078090	1.162735	1.254544	1.354186	1.462402	1.580008	1.707908	1.847103	1.998700
6	1.094344	1.197983	1.311909	1.437226	1.575170	1.727122	1.894629	2.079425	2.283454
7	1.110816	1.234186	1.371622	1.524835	1.695757	1.886579	2.099782	2.328184	2.604983
8	1.127510	1.271683	1.433775	1.617249	1.824674	2.059356	2.325085	2.626221	2.967777
9	1.144428	1.309553	1.498459	1.714717	1.962465	2.246502	2.572408	2.946671	3.376850
10	1.161572	1.248767	1.565773	1.817500	2.110704	2.449150	2.843790	3.302994	3.837811
11	1.178946	1.389036	1.635818	1.925871	2.267007	2.668514	3.141452	3.699005	4.356920
12	1.196553	1.430387	1.708698	2.040118	2.435023	2.905904	3.467811	4.138913	4.941171
13	1.214394	1.472848	1.784521	2.160541	2.614446	3.162727	3.825503	4.627356	5.598371
14	1.232475	1.516446	1.863400	2.287458	2.806010	3.440496	4.217394	5.169449	6.337235
15	1.250796	1.561210	1.945450	2.421201	3.010497	3.740840	4.646606	5.770831	7.167488
16	1.269362	1.607169	2.030794	2.562117	3.238736	4.065508	5.116537	6.437712	8.099980
17	1.288175	1.654345	2.119556	2.711573	3.461607	4.416382	5.630887	7.176936	9.146812
18	1.307239	1.702796	2.211866	2.866952	3.710048	4.795485	6.193678	7.996043	$^{1}1.032148$
19	1.326557	1.752525	2.307858	3.031657	3.975051	5.204990	6.809288	8.903335	$^{1}1.163903$
20	1.346131	1.803576	2.407672	3.205111	4.257673	5.647234	7.482482	9.907955	$^{1}1.311624$
21	1.365966	1.855980	2.511452	3.387755	4.559033	6.124729	8.218440	$^{1}1.101997$	$^{1}1.477180$
22	1.386064	1.909772	2.619350	3.580055	4.880320	6.640173	9.022796	$^{1}1.225046$	$^{1}1.662653$
23	1.406428	1.964986	2.731518	3.782498	5.222799	7.196464	9.901677	$^{1}1.361162$	$^{1}1.870364$
24	1.427063	2.021659	2.848120	3.995597	5.587809	7.796717	$^{1}1.086174$	$^{1}1.511688$	$^{1}2.102898$
25	1.447971	2.079827	2.969321	4.219889	5.976774	8.444278	$^{1}1.191024$	$^{1}1.679099$	$^{1}2.363133$
26	1.469156	2.139526	3.095295	4.455931	6.391204	9.142741	$^{1}1.304504$	$^{1}1.862022$	$^{1}2.654274$
27	1.490620	2.200796	3.226221	4.704319	6.832701	9.895965	$^{1}1.430470$	$^{1}2.065241$	$^{1}2.979888$
28	1.512369	2.263285	3.362285	4.965670	7.302968	$^{1}1.070809$	$^{1}1.566852$	$^{1}2.289876$	$^{1}3.343947$
29	1.534405	2.328206	3.503679	5.240633	7.803810	$^{1}1.158359$	$^{1}1.715660$	$^{1}2.537656$	$^{1}3.750870$
30	1.556732	2.394427	3.650603	5.529888	8.337141	$^{1}1.252721$	$^{1}1.877992$	$^{1}2.811366$	$^{1}4.205574$

TABLE 3. VALUES OF $F(a, 3; 2; x)$ (*Contd.*)

a \ x	.1	.2	.3	.4	.5	.6	.7	.8	.9	.95
0.5	1.083373	1.187911	1.323289	1.506160	1.767767	2.174066	2.890758	4.472136	11.027740	12.571478
1.5	1.268815	1.659582	2.256299	3.227483	4.949747	8.399801	11.673597	14.472136	22.450765	31.364001
1	1.172840	1.406250	1.734694	2.222222	3.000000	4.375000	7.222222	11.500000	15.500000	22.100000
2	1.371742	1.953125	2.915452	4.629630	8.000000	11.562500	13.703704	21.250000	31.000000	38.000000
3	1.600366	2.685547	4.789671	9.259259	12.000000	15.078125	21.666667	28.750000	41.450000	52.360000
4	1.862860	3.662109	7.734872	11.800412	14.800000	21.562500	26.995885	35.625000	51.900000	66.240000
5	2.163928	4.959106	11.232480	13.429355	21.200000	24.638672	32.812071	43.437500	62.350000	81.552000
6	2.508902	6.675720	11.942825	16.430041	22.560000	31.342773	41.097394	52.031250	72.800000	93.712000
7	2.903822	8.940697	13.035664	21.190748	25.760000	33.814697	44.191434	61.171875	83.250000	108.640000
8	3.355527	11.192093	14.708377	22.183039	31.280000	41.068115	51.574963	66.140625	93.700000	121.971200
9	3.871762	11.583248	17.257273	23.969161	32.816000	42.956390	55.842605	73.710937	104.150000	134.428000
10	4.461290	12.095476	21.112613	27.166541	36.144000	48.106232	62.145111	82.050781	114.600000	149.830400
11	5.134024	12.764864	21.697819	31.286302	41.331200	52.205372	67.808957	91.123047	125.050000	162.160640
12	5.901177	13.637979	22.580272	32.296968	42.876200	55.960464	72.822515	96.103516	135.500000	174.710400
13	6.775425	14.774847	23.907269	34.083499	46.144000	61.601875	81.014015	103.295898	145.950000	191.019904
14	7.771097	16.252776	25.897765	37.231197	51.310720	64.284084	83.623969	111.770020	156.400000	202.195456
15	8.904382	18.171242	28.876738	41.276094	52.785280	71.140870	91.289297	119.460449	166.850000	214.702208
16	11.019357	21.065814	31.332585	42.244979	55.898240	73.026789	94.568679	125.035400	177.300000	231.002701
17	11.165931	21.387779	31.995807	43.938560	61.245184	78.003553	101.613234	132.670288	187.750000	242.219920
18	11.332493	21.804112	32.982745	46.892480	62.621440	82.110028	105.678585	141.411438	198.200000	254.508877
19	11.521674	22.341877	34.449053	51.203449	65.505024	85.547918	111.993241	147.438660	208.650000	269.515827
20	11.736444	23.035766	36.624344	52.096919	71.153434	91.455192	116.978732	153.910065	219.100000	282.002780
21	11.980156	23.930233	39.846998	53.646815	72.411725	93.808509	122.437776	162.050400	229.550000	294.204790
22	12.256588	25.082198	41.461521	56.331276	75.033165	99.947598	128.497695	171.072884	241.000000	308.808038
23	12.570003	26.564505	42.166183	61.097421	81.048576	102.593481	132.956490	175.602837	251.450000	321.841299
24	12.925207	28.470329	43.206398	61.899383	82.181038	106.750156	141.026805	182.920628	261.900000	333.841982
25	13.327616	31.091878	44.740356	63.282884	84.529848	111.754152	143.560377	191.519918	272.350000	348.002732
26	13.783336	31.406207	47.000205	65.666883	89.395241	114.551914	151.232690	197.897615	282.800000	361.664300
27	14.299246	31.809458	51.032639	69.770488	91.946157	121.179612	154.261961	204.097819	293.250000	373.456106
28	14.883094	32.327445	51.521784	71.682695	94.026532	123.053113	161.471652	212.123415	303.700000	387.167227
29	15.543609	32.988836	52.250527	72.894959	98.321499	127.892992	165.075498	221.098961	314.150000	401.484448
30	16.290620	33.837019	53.295825	74.975711	101.717987	132.038300	171.748497	225.681068	324.600000	413.070902

TABLE 4. VALUE OF $F(a, 4; 3; x)$

a \ x	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.5	1.006730	1.031589	1.020580	1.027709	1.034978	1.042394	1.049960	1.057682	1.065564
1.5	1.020318	1.041287	1.062936	1.085296	1.108398	1.132276	1.156965	1.182501	1.208926
1	1.013502	1.027350	1.041556	1.056134	1.071099	1.086464	1.102247	1.118463	1.135129
2	1.027175	1.055399	1.084726	1.115210	1.146912	1.179893	1.214220	1.249966	1.287205
3	1.041020	1.084166	1.129570	1.177376	1.227738	1.280821	1.336805	1.395882	1.458258
4	1.055041	1.113667	1.176150	1.242785	1.313895	1.389828	1.470965	1.557723	1.650556
5	1.069238	1.143921	1.224531	1.311602	1.405720	1.507531	1.617747	1.737156	1.866627
6	1.083615	1.174945	1.274780	1.383996	1.503571	1.634598	1.778292	1.936016	2.109292
7	1.098173	1.206760	1.326965	1.460145	1.607829	1.771744	1.953840	2.156325	2.381699
8	1.112915	1.239384	1.381159	1.540237	1.718896	1.919738	2.145740	2.400309	2.687357
9	1.127842	1.272836	1.437436	1.624469	1.837201	2.097407	2.355458	2.670421	3.030178
10	1.142957	1.307138	1.495873	1.713046	1.963197	2.251637	2.584591	2.969358	3.414523
11	1.158263	1.342310	1.556549	1.806184	2.097367	2.437383	2.834871	3.300093	3.845254
12	1.173761	1.378373	1.619548	1.904110	2.240222	2.637667	3.108186	3.665894	4.327784
13	1.189454	1.415349	1.684955	2.007060	2.392304	2.853588	3.406585	4.070359	4.868149
14	1.205345	1.453261	1.752859	2.115284	2.554189	3.086328	3.732294	4.517447	5.473067
15	1.221435	1.492130	1.823351	2.229042	2.726487	3.337152	4.187736	5.011511	6.150022
16	1.237727	1.531980	1.896527	2.348607	2.909848	3.607423	4.475539	5.557341	6.907345
17	1.254223	1.572835	1.972485	2.474267	3.104957	3.898599	4.898564	6.160203	7.754312
18	1.270927	1.614720	2.051327	2.606320	3.313543	4.212250	5.359913	6.825890	8.701284
19	1.287840	1.657659	2.133159	2.745083	3.533379	4.55057	5.862961	7.560769	9.759642
20	1.304965	1.701680	2.218091	2.890884	3.768385	4.913827	6.411370	8.371838	11.094228
21	1.322305	1.746805	2.306236	3.044069	4.018131	5.305498	7.009120	9.266794	11.226339
22	1.339862	1.793064	2.397712	3.205001	4.283837	5.727149	7.660531	11.025409	11.373876
23	1.357638	1.840483	2.492640	3.374060	4.566382	6.181012	8.370293	11.134302	11.538603
24	1.375637	1.889091	2.591147	3.551642	4.866802	6.669481	9.143502	11.254379	11.722475
25	1.393861	1.938170	2.693362	3.738161	5.186195	7.195125	9.985687	11.386763	11.927666
26	1.412313	1.989990	2.799421	3.934065	5.525728	7.760699	11.090285	11.532684	12.156589
27	1.430996	2.042339	2.909465	4.139800	5.886635	8.369159	11.190151	11.693498	12.411957
28	1.449911	2.095997	3.023637	4.355851	6.270225	9.023677	11.298874	11.870791	12.696731
29	1.469063	2.150994	3.142089	4.582717	6.677887	9.727652	11.417220	12.065912	13.014243
30	1.488454	2.207362	3.264976	4.820918	7.111091	11.048473	11.546024	12.280920	13.368181

TABLE 4. VALUES OF $F(a, 4; 3; x)$ (*Contd.*)

a \ x	.1	.2	.3	.4	.5	.6	.7	.8	.9	.95
0.5	1.073613	1.164919	1.280602	1.434438	1.649916	1.976424	2.535753	3.726780	7.905695	11.863390
1.5	1.236281	1.572235	2.073355	2.868875	4.242640	6.917483	11.318591	13.318102	21.739353	29.391484
1	1.152263	1.354167	1.632653	2.037037	2.666667	3.750000	5.925926	11.166667	14.000000	21.466667
2	1.326017	1.822917	2.623907	4.012346	6.666667	11.250000	12.839506	19.166667	27.000000	35.466667
3	1.524158	2.441406	4.164931	7.716049	11.600000	13.906250	21.234568	26.250000	41.000000	51.600000
4	1.74959	3.255208	6.544892	11.457476	13.733333	21.171875	25.075446	33.958333	51.300000	64.213333
5	2.007122	4.323324	11.019983	12.714906	18.533333	23.417969	32.011888	42.395833	61.600000	81.045333
6	2.299827	5.722046	11.578545	15.001143	11.920000	29.765625	37.773205	51.406250	71.900000	92.496000
7	2.632789	7.549922	12.428531	19.129071	24.266667	32.746582	42.946705	58.072917	82.200000	105.902667
8	3.011371	9.934107	13.717140	21.653817	29.386667	37.629395	51.100781	64.557292	92.500000	121.322667
9	3.441566	11.303852	15.664213	22.976871	32.048000	42.098083	54.064421	72.539063	102.800000	132.969600
10	3.930184	11.707425	18.597466	25.328966	34.437333	45.722046	61.486524	81.399740	113.100000	146.587733
11	4.484894	12.231294	21.300457	29.494136	39.557333	51.549721	65.394139	87.649740	123.400000	161.447253
12	5.114353	12.910383	21.961007	31.684443	42.048000	54.172325	71.944399	94.150391	133.700000	173.153920
13	5.828323	13.789561	22.948882	32.977552	44.369667	61.117587	76.969172	102.237956	144.000000	186.826667
14	6.637812	14.926430	24.423323	35.246162	49.284267	62.980232	82.485671	111.200358	154.300000	201.464899
15	7.555233	16.394885	26.619940	39.216231	51.966080	67.916242	88.827618	116.408691	164.600000	213.146088
16	8.594578	18.289665	29.886923	41.614810	54.150613	72.095476	93.123222	123.407796	174.900000	226.706517
17	9.771613	21.073216	31.473827	42.822635	58.738133	75.529728	101.101301	131.805623	185.200000	241.424316
18	11.110411	21.387779	32.193195	44.923200	61.835008	81.455191	103.871762	139.536743	195.500000	253.014656
19	11.261207	21.792548	33.258461	48.570015	63.844779	83.819788	111.357507	145.022685	205.800000	266.361361
20	11.431805	22.312965	34.833981	51.489116	68.039083	91.000444	114.748087	152.638499	216.100000	281.338682
21	11.624743	22.981556	37.161453	52.583161	71.677722	92.614797	121.657050	161.382828	226.400000	292.810184
22	11.842880	23.839833	41.059603	54.474102	73.495253	96.821210	125.771351	167.232030	236.700000	305.886007
23	12.089433	24.941026	41.565915	57.783226	77.270127	101.776357	132.006400	173.774961	247.000000	321.230329
24	12.368024	26.352747	42.311589	61.336603	81.509949	104.618528	136.963722	181.966953	257.300000	332.566914
25	12.682729	28.161515	43.408795	62.305835	83.131747	111.199041	142.412926	191.023213	267.600000	345.346339
26	13.038598	31.047762	45.021886	63.973332	86.487190	113.108624	148.349073	195.314747	277.900000	361.111770
27	13.439396	31.344168	47.391521	66.839341	91.342177	118.049117	152.885169	202.756715	288.200000	372.308545
28	13.892321	31.723293	51.086988	71.176077	92.773833	122.081668	159.956718	211.428028	298.500000	384.787099
29	14.403434	32.207969	51.597207	72.020440	95.726623	125.377643	163.432235	217.388492	308.800000	399.914216
30	14.980074	32.827278	52.345106	73.467920	101.181116	131.387779	171.181423	223.818423	319.100000	412.050849

TABLE 5. VALUES OF $F(a, 3; 1; x)$

x a	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.5	1.015228	1.030926	1.047113	1.063811	1.081043	1.098832	1.117205	1.136187	1.155806
1	1.030611	1.062482	1.095683	1.130281	1.166351	1.203872	1.243229	1.284211	1.327015
2	1.061841	1.127532	1.197344	1.271566	1.350511	1.434520	1.523958	1.619223	1.720745
3	1.093702	1.195237	1.305492	1.424625	1.554057	1.694500	1.846948	2.012498	2.192355
4	1.126205	1.265688	1.419856	1.590275	1.778689	1.987042	2.217948	2.472479	2.754683
5	1.159361	1.338977	1.541369	1.769385	2.022624	2.315577	2.641512	3.008712	3.422472
6	1.193180	1.415201	1.670189	1.962878	2.298693	2.683864	3.125548	3.631979	4.212630
7	1.227672	1.494456	1.806687	2.171734	2.598178	3.096014	3.767901	4.354443	5.144535
8	1.262851	1.576848	1.951252	2.396994	2.926995	3.556528	4.303670	5.189825	6.240368
9	1.298727	1.662480	2.140288	2.639762	3.287622	4.070329	5.014846	6.153578	7.525496
10	1.335312	1.751460	2.266220	2.901210	3.682730	4.642794	5.820405	7.263106	9.028904
11	1.372617	1.843899	2.437459	3.182584	4.115190	5.279804	6.731406	8.537985	$^{1}1.078368$
12	1.410654	1.939913	2.618574	3.485201	4.588096	5.987779	7.760109	$^{1}1.000023$	$^{1}1.282757$
13	1.449436	2.039620	2.809943	3.810462	5.104781	6.773731	8.920085	$^{1}1.167457$	$^{1}1.520360$
14	1.488976	2.143140	3.012111	4.159854	5.668822	7.645309	$^{1}1.022636$	$^{1}1.358879$	$^{1}1.796077$
15	1.529283	2.250601	3.225605	4.534947	6.284076	8.610861	$^{1}1.169558$	$^{1}1.577404$	$^{1}2.115486$
16	1.570377	2.362129	3.450983	4.937413	6.954685	9.679941	$^{1}1.334613$	$^{1}1.826530$	$^{1}2.484929$
17	1.612262	2.477863	3.688821	5.369021	7.685099	$^{1}1.086113$	$^{1}1.519833$	$^{1}2.110175$	$^{1}2.911618$
18	1.654956	2.597932	3.939723	5.831642	8.480109	$^{1}1.216658$	$^{1}1.727467$	$^{1}2.432730$	$^{1}3.403730$
19	1.698472	2.722482	4.204327	6.327266	9.394859	$^{1}1.360763$	$^{1}1.959997$	$^{1}2.799113$	$^{1}3.970597$
20	1.742822	2.851659	4.483284	6.857992	$^{1}1.028487$	$^{1}1.519713$	$^{1}2.220163$	$^{1}3.214826$	$^{1}4.622736$
21	1.788023	2.985610	4.777291	7.426058	$^{1}1.130607$	$^{1}1.694904$	$^{1}2.510991$	$^{1}3.686028$	$^{1}5.372119$
22	1.834085	3.124490	5.087063	8.033813	$^{1}1.241485$	$^{1}1.887858$	$^{1}2.835817$	$^{1}4.219603$	$^{1}6.232304$
23	1.881022	3.268459	5.413353	8.683763	$^{1}1.361803$	$^{1}2.100229$	$^{1}3.198324$	$^{1}4.823249$	$^{1}7.218647$
24	1.928852	3.417680	5.756952	9.378553	$^{1}1.492296$	$^{1}2.333819$	$^{1}3.602568$	$^{1}5.505565$	$^{1}8.348538$
25	1.977590	3.572319	6.118671	$^{1}1.012099$	$^{1}1.633751$	$^{1}2.590585$	$^{1}4.053024$	$^{1}6.276153$	$^{1}9.641649$
26	2.027240	3.732549	6.499370	$^{1}1.091402$	$^{1}1.787015$	$^{1}2.872657$	$^{1}4.554616$	$^{1}7.145733$	$^{2}1.112024$
27	2.077839	3.898555	6.899910	$^{1}1.170080$	$^{1}1.952990$	$^{1}3.182350$	$^{1}5.112777$	$^{1}8.130386$	$^{2}1.280947$
28	2.129376	4.070510	7.321318	$^{1}1.266463$	$^{1}2.132654$	$^{1}3.522178$	$^{1}5.733479$	$^{1}9.227700$	$^{2}1.473779$
29	2.181880	4.248612	7.764471	$^{1}1.362905$	$^{1}2.327043$	$^{1}3.894873$	$^{1}6.423303$	$^{2}1.047525$	$^{2}1.693730$

TABLE 5. VALUES OF $F(a, 3; 1; x)$ (*Contd.*)

a \ x	.1	.2	.3	.4	.5	.6	.7	.8	.9	.95
0.5	1.176094	1.423746	1.789794	2.366823	3.358757	5.286933	9.813362	12.459675	21.276770	26.948581
1	1.371742	1.953125	2.915452	4.629630	8.000000	11.562500	13.703704	21.250000	31.000000	38.000000
2	1.828989	3.417969	6.663890	11.388889	13.200000	18.593750	22.962963	31.625000	42.800000	54.640000
3	2.387847	5.615234	11.362528	13.549383	21.040000	23.671875	31.765432	41.512500	55.410000	71.824800
4	3.067133	8.850098	12.609457	18.316187	23.040000	31.386398	39.149520	51.206250	68.830000	86.020800
5	3.888789	11.354218	14.784207	21.843278	28.320000	34.858398	44.362140	58.781250	81.306000	101.835392
6	4.878420	12.026559	18.499860	23.929470	32.176000	41.617432	51.966164	66.015625	91.810000	114.961600
7	6.065761	12.980232	21.474465	28.136781	35.504000	45.187988	58.509882	73.945313	102.395000	131.328000
8	7.585407	14.321337	22.509954	31.647202	41.356800	51.617432	63.571610	82.503906	113.061000	143.405056
9	9.177510	16.193295	24.207701	33.274558	43.276800	54.930496	71.463192	91.548828	123.808000	158.498056
10	11.118863	18.789357	26.964670	36.413136	47.782400	61.475811	75.878357	99.384766	134.636000	172.072166
11	11.357271	21.236913	31.140480	41.240363	51.822720	64.351139	82.323870	105.590820	145.545000	184.965376
12	11.639216	21.728040	31.850424	42.373534	54.218880	71.266599	89.063408	113.283691	156.535000	201.192070
13	11.971916	22.398792	32.978371	44.500356	59.666560	73.647059	93.494343	121.905518	167.606000	212.731704
14	12.363709	23.311129	34.760339	48.464754	62.195456	81.040287	101.333900	131.094360	178.758000	226.297682
15	12.824218	24.547473	37.561347	51.580938	64.947968	82.942979	105.048004	136.228638	189.991000	241.433534
16	13.364549	26.217249	41.194414	52.934227	71.107558	88.265488	111.895873	143.517151	201.130500	253.257467
17	13.997478	28.465451	41.877375	55.415520	72.464154	92.306478	117.072419	151.972198	211.270000	267.324303
18	14.737752	31.148387	42.937628	59.944864	75.492595	96.349205	122.622474	161.099014	221.417600	281.636198
19	15.602318	31.552578	44.577959	61.817937	81.200620	101.766239	129.671758	166.090164	231.573300	293.633997
20	16.610674	32.092510	47.107742	63.309485	82.631926	104.852154	133.549593	173.357887	241.737100	308.029051
21	17.785229	32.812149	51.099795	66.002050	85.746196	111.327294	141.296961	181.842976	251.909000	321.765592
22	19.151718	33.769296	51.696408	71.084759	91.249903	113.616662	144.719761	191.007319	262.089000	333.865890
23	21.073969	35.003985	52.609113	71.954254	92.709520	119.819700	151.711223	195.484819	272.277100	348.431474
24	21.258303	36.723324	54.002139	73.510341	95.855248	122.657430	156.183253	202.976060	282.473300	361.832290
25	21.472062	38.950094	56.123658	76.288286	101.261647	127.169820	162.227235	211.609623	292.677600	373.968684
26	21.717698	41.189072	58.348100	81.123606	102.711198	131.929012	167.999373	218.679926	302.890000	388.569802
27	22.006314	41.576813	61.423955	82.002950	105.811628	135.176415	172.865349	224.667789	313.110500	401.845292
28	22.337751	42.087339	62.164660	83.562607	111.242656	141.385697	181.023794	232.503768	323.333910	413.962939
29	22.720693	42.758615	63.284416	86.323677	112.652142	143.701032	183.649502	241.339801	333.575800	428.489969

TABLE 6. VALUES OF $F(a, 1; 2; x)$

x a	.01	.02	.03	.04	.05	.06	.07	.08	.09
1.0	1.005034	1.010135	1.015307	1.020550	1.025866	1.031257	1.036724	1.042143	1.047896
1.5	1.007560	1.015250	1.023080	1.031035	1.039336	1.047373	1.055763	1.064302	1.072996
2	1.010101	1.020408	1.030928	1.041667	1.052632	1.063830	1.075269	1.086957	1.098901
3	1.015203	1.030821	1.046870	1.063368	1.080332	1.097782	1.115736	1.134215	1.153242
4	1.020338	1.041375	1.063141	1.085672	1.109005	1.133179	1.158234	1.184214	1.211167
5	1.025509	1.052072	1.079748	1.108598	1.138688	1.170089	1.202877	1.237131	1.272939
6	1.030714	1.062916	1.096699	1.132165	1.169422	1.208587	1.249786	1.293157	1.338848
7	1.035955	1.073908	1.114003	1.156393	1.201247	1.248747	1.299092	1.352498	1.409201
8	1.041231	1.085051	1.126705	1.181304	1.234208	1.290651	1.350929	1.415371	1.484334
9	1.046042	1.096347	1.149699	1.206917	1.268349	1.334382	1.405444	1.482010	1.564607
10	1.051890	1.107797	1.168109	1.233257	1.303719	1.380031	1.462790	1.552667	1.650410
11	1.057274	1.119406	1.186906	1.260345	1.340365	1.427689	1.523130	1.627609	1.742164
12	1.062694	1.131742	1.206097	1.288205	1.378340	1.477455	1.586638	1.707123	1.840323
13	1.068151	1.143105	1.225693	1.316863	1.417696	1.529433	1.653496	1.791518	1.945381
14	1.073645	1.155201	1.245701	1.346342	1.458490	1.583731	1.723900	1.881215	2.057867
15	1.079176	1.167464	1.266137	1.376670	1.500780	1.640464	1.798057	1.976287	2.178351
16	1.084745	1.179898	1.287005	1.407874	1.544626	1.699752	1.876186	2.077393	2.307473
17	1.090352	1.192505	1.308316	1.439981	1.590092	1.761721	1.958521	2.184843	2.445885
18	1.095997	1.205287	1.330083	1.473021	1.637242	1.826504	2.045309	2.299072	2.594322
19	1.101681	1.218247	1.352314	1.507023	1.686147	1.894242	2.136813	2.420545	2.753570
20	1.107404	1.231388	1.375022	1.542018	1.736878	1.965081	2.233313	2.549760	2.924480
21	1.113165	1.244713	1.398217	1.578039	1.789510	2.039178	2.335105	2.687253	3.107974
22	1.118966	1.258224	1.421912	1.615118	1.844120	2.116695	2.442503	2.833595	3.305048
23	1.124806	1.271925	1.446118	1.653261	1.900791	2.197804	2.555844	2.989402	3.516784
24	1.130687	1.285819	1.470847	1.692589	1.959606	2.282687	2.675483	3.155337	3.744350
25	1.136608	1.299908	1.496111	1.733053	2.020656	2.371534	2.801796	3.332095	3.989013
26	1.142569	1.314195	1.521925	1.774720	2.084031	2.464545	2.935188	3.520447	4.252146
27	1.148571	1.328685	1.548300	1.817628	2.149829	2.561932	3.076083	3.721203	4.535235
28	1.154615	1.343379	1.575250	1.861818	2.218150	2.663918	3.224937	3.935236	4.839890
29	1.160700	1.358281	1.602789	1.907333	2.289099	2.770737	3.382231	4.132420	5.167858
30	1.166827	1.373394	1.630931	1.954214	2.362787	2.882635	3.548479	4.407002	5.521032

TABLE 6. VALUES OF $F(a, 1 ; 2 ; x)$ (*Contd.*)

a \ x	.1	.2	.3	.4	.5	.6	.7	.8	.9	.95
1.0	1.053605	1.115709	1.188842	1.276713	1.386286	1.527167	1.719957	2.011800	2.558433	3.155053
1.5	1.081852	1.180340	1.301524	1.454972	1.656854	1.937129	2.359262	3.099170	4.805061	7.309760
2	1.111111	1.250000	1.428571	1.666667	2.000000	2.500000	3.333333	5.000000	11.000000	12.000000
3	1.171854	1.406250	1.734694	2.222222	3.000000	4.375000	7.222222	11.500000	15.500000	22.100000
4	1.239140	1.588542	2.128280	3.024691	4.666667	9.125000	11.716049	15.166667	23.700000	32.806667
5	1.310395	1.802758	2.637443	4.197531	7.500000	11.585937	14.373457	21.950000	32.777500	44.210500
6	1.387018	2.051758	3.299993	5.930041	11.240000	13.221875	21.172922	27.810000	42.222200	56.736840
7	1.469461	2.345581	4.166589	8.513946	12.133333	16.753906	23.916406	33.255000	51.851850	71.122807
8	1.558216	2.716943	5.306027	11.446769	13.628571	21.450837	31.088446	41.395071	61.587301	81.924812
9	1.653822	3.100290	6.811105	11.829294	16.375000	23.176831	32.721532	46.103500	71.388889	93.368421
10	1.756861	3.583656	8.807752	12.728584	21.135556	27.062402	38.064169	52.712672	81.234568	105.988304
11	1.867972	4.156613	11.146711	14.109546	22.046000	31.589291	42.49284	61.220703	91.111111	121.077895
12	1.987851	4.837060	11.502222	16.241732	23.721818	33.612251	47.331194	65.548650	101.010101	131.959809
13	2.117255	5.646631	11.979101	19.549868	26.825000	38.278284	52.240090	72.543132	109.259259	143.592982
14	2.257014	6.611498	12.620792	21.470493	31.260154	41.910392	56.892587	81.173753	118.547009	156.633198
15	2.408030	7.763346	13.486764	22.276953	32.344286	44.434857	62.133420	85.449567	127.936508	171.231880
16	2.571291	9.140570	14.658543	23.543033	34.368933	51.034802	66.637307	92.543132	137.407407	182.299509
17	2.747272	11.078973	16.248049	25.537038	38.191875	52.425318	72.074158	101.192093	146.944444	194.311579
18	2.938951	11.276733	18.409142	28.686530	41.542012	55.706632	76.507180	105.609849	156.535948	208.115913
19	3.145813	11.514199	21.135360	31.367417	42.912700	61.347399	82.048551	112.649095	166.172839	221.533006
20	3.369862	11.799709	21.537330	32.159167	45.518811	63.191209	86.469110	121.254835	175.847953	232.904643
21	3.612632	12.143404	22.087091	33.418752	51.048575	67.579122	92.048551	125.960464	185.555555	245.518821
22	3.875801	12.557624	22.840259	35.426689	51.997287	71.804553	96.503338	132.838316	195.291005	261.051204
23	4.161203	13.057392	23.873730	38.633444	53.813027	74.306319	102.069244	141.354651	205.050505	272.006844
24	4.470843	13.661013	25.293917	41.376353	57.294441	81.029772	106.597589	146.478766	214.830918	283.839180
25	4.806917	14.390797	27.248220	42.198349	61.398101	82.467162	112.107563	153.104409	224.629630	297.358843
26	5.171822	15.273956	29.940986	43.517366	62.684353	85.921189	116.744202	161.490116	234.444444	311.412818
27	5.568186	16.343697	31.365575	45.636810	65.162220	91.423363	122.161603	167.164020	244.273503	322.716958
28	5.998882	17.649561	31.887862	49.046739	69.942054	93.426614	126 938480	173.449343	254.115226	335.232660
29	6.467056	19.214069	32.587944	51.453941	71.917396	98.260587	132.230226	181.663076	263.968253	351.009156
30	6.976152	21.112474	33.569633	52.339675	73.702558	101.993935	137.177738	188.028642	273.831418	361.948715

A NOTE ON STRATIFICATION IN UNEQUAL PROBABILITY SAMPLING

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SUMMARY. It is shown in this note that in case of unequal probability sampling the criterion for stratification should be the ratio of the value of the characteristic under consideration to the size of the unit and that equalization of strata sizes need not necessarily be the best procedure.

1. The problem considered

Suppose a universe is divided up into k strata and n_i units are selected from the i-th stratum with replacement with probabilities

$$p_{ij} = x_{ij}/X_i (j = 1, 2, \ldots, n_i) \qquad \ldots \quad (1.1)$$

where X_i is the size of the i-th stratum.

It is well known that the variance of the estimate

$$\hat{Y} = \sum_i \frac{1}{n_i} \mathop{S}_j \frac{y_{ij}}{p_{ij}} \qquad \ldots \quad (1.2)$$

is given by

$$V(\hat{Y}) = \sum_i \frac{X_i}{n_i} \sum_j x_{ij} \left(\frac{y_{ij}}{x_{ij}} - R_i \right)^2 \qquad \ldots \quad (1.3)$$

where

$$R_i = Y_i/X_i .$$

If the total sample size of n is allocated to the strata in proportion to their size, i.e.

$$n_i = n \, X_i/X$$

we have

$$V_{(\hat{Y}x\text{-prop})} = \frac{X}{n} \; \Sigma \; \Sigma x_{ij} \left(\frac{y_{ij}}{x_{ij}} - R_i \right)^2 . \qquad \ldots \quad (1.4)$$

This allocation may be called x-proportional to distinguish it from the N-proportional allocation used in equal probability sampling.

Comparing it with the situation in which no stratification is made, it is easy to see that

$$V_{(\hat{Y}\text{unst})} - V_{(\hat{Y}x\text{-prop})} = \frac{X}{n} \, \Sigma \, X_i (R_i - R)^2$$

$$= \frac{X}{n} \, [\Sigma (X_i - \tilde{X})(R_i - R)^2 + \tilde{X} \, \Sigma (R_i - R)^2] \qquad \ldots \quad (1.5)$$

where $\tilde{X}$ is the average size of a stratum and R is the ratio of y to x in the entire universe.

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This shows that stratification with x-proportional allocation is always superior to no stratification. But the gains from stratification will be considerable only if the strata ratios R_i differ considerably from each other. In fact the best stratification would be that for which

$$Q = \Sigma(X_i - \tilde{X})(R_i - R)^2 + \tilde{X}\Sigma(R_i - R)^2 \qquad \ldots \quad (1.6)$$

is a maximum.

If the strata are of equal size the first part of Q would be zero. For unequal strata, the first part is generally expected to be small with either sign. There is, therefore, no guarantee that strata with equal size would be necessarily the best thing to have. If the strata ratios R_i could be made to differ more widely by making strata of unequal size, obviously the use of unequal strata would be more beneficial (see Section 2 for an example). It must, however, be pointed out that there are certain practical advantages in making strata of equal size.

2. An example

The main points stated in Section 1 will now be illustrated with the help of an example taken from Cochran (1953). The problem is to estimate the total population of 64 U.S. cities in 1930 from a sample of 16 cities selected with probabilities proportionate to 1920 populations. Eight strata are formed and various modes of stratification are tried, the sample allocation to strata being x-proportional in each case. Following one practice, the cities are ranked in descending order according to 1920 populations (called x) and strata are made of equal size (as judged by x) by cutting the distribution thus formed at suitable points. The strata ratios have a range of (1.08, 1.43) and the coefficient of variation of the estimate is found to be 4.24 percent as compared to 4.88 percent when no stratification is made. The poor performance of this technique is due to the fact that the rate of increase of cities within some strata is highly variable. A simple modification is then introduced. Seven cities are identified as those which have increased at a tremendous rate (and these include only one large city) and these are divided up into two strata. The other cities are ranked according to x as before and six strata made of about equal size. The coefficient of variation comes down to 1.72 percent, the range of strata ratios being (1.08, 2.14). This shows how important it is to be able to pick out units (using whatever knowledge available) with unusual y/x and sample them separately. It is of interest to note that these unusual units may not necessarily be the largest ones. Next, the cities are ranked according to y/x. This may not be a realistic procedure but is given here for purposes of comparison only. If the strata are made of equal size, the range of the strata ratios is (1.02, 1.69) and the relative error is found to be 2.53 percent. If, however, the restriction of equality of strata sizes is relaxed in order to achieve greater homogeneity within strata with respect to y/x, the relative error comes down to 0.66 percent, the range of strata ratios being (0.95-2.14).

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A PRELIMINARY NOTE ON THE CONSUMPTION OF CEREALS IN INDIA*

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INTRODUCTION

There has been a good deal of difference of opinion about the actual level of consumption of cereals in India, especially since the National Sample Survey[1] (NSS) started making estimates of per capita consumption about ten years ago. The estimates of aggregate consumption were obtained by multiplying the total population by the per capita consumption; and such estimates were found to be consistently much higher than the estimates of production of the Ministry of Food and Agriculture which were based essentially on the so-called 'complete enumeration' of the area sown by *patwaris* (employees of the Revenue Department) at the village level. The NSS estimates based on per capita consumption have been consistently higher by something of the order of twenty-five per cent or more. It is pertinent to mention that traditional estimates, based on complete enumeration, when checked by sample surveys or compared with other independent estimates, have shown similar underestimation even in the U.S.A.; and a similar gap in Japan was reported in a paper presented last year (1960) at the Tokyo Session of this Institute.[2]

2. Aggregate estimates of consumption based on per capita consumption involve the use of the estimate of total population. In India the estimate of population based on the Census of this year (1961) is now available; it is, therefore, possible to calculate the aggregate consumption based on the Census figure. Very recently, the National Sample Survey has obtained independent estimates of production of cereals for India as a whole based on sample surveys, by direct physical observation of the area sown in sample plots of land, and estimates of yield per acre based on direct crop-cutting experiments using probability samples. Also, as a design of 'inter-penetrating network of samples' (IPNS) is used in the NSS, at least two independent estimates are available; and the difference between the two estimates supplies the margin of uncertainty which can be used for statistical comparisons in a valid manner.

3. In the present note a preliminary examination has been made of the NSS data on consumption of cereals in India in the 8th round (July 1954 – March 1955) and the 13th round (September 1957 – May 1958). These two rounds have been selected because there was a large increase in prices and especially in the price of cereals during the interval of about three years. Using the period of survey of the 8th round as the base (= 100), the general index of prices[3] rose to 112 during the period of survey of the 13th round; the corresponding index number of the price of cereals was 136 and that of rice 145.

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[1] The National Sample Survey of India was started in 1950 and is being conducted since then in the form of successive rounds covering the whole of India. A multi-stage stratified design with inter-penetrating network of sub-samples (IPNS) has been used from the very beginning. The 17th round of the survey was started in July 1961.

[2] Y. Tumura : Role of Census in Countries Conducting Various Special Surveys. *Bulletin of the International Statistical Institute*, 38, Part 2, Tokyo, 1961.

[3] Index number of wholesale prices in India (Revised Series) : Issued by the office of the Economic Adviser to the Government of India.

4. The comparison of prices, expenditure and consumption of cereals in these two rounds gives a remarkably coherent picture. Using the results of this comparative study, estimates have also been made of the aggregate consumption of cereals with the help of the population figures based on the Census of 1961. Finally, the aggregate estimates of consumption have been compared, in a rough way, with completely independent estimates of production based on direct sample surveys of both area sown and of yield per acre conducted by the NSS.

FRACTILE GRAPHICAL ANALYSIS

5. The method of Fractile Graphical Analysis[4] (FGA) has been used for the comparison of the NSS consumption data. Two independent sub-samples of the data collected by the Central Government, called sub-samples 1 and 2, and the combined sample (obtained by pooling the two sub-samples) were used throughout. In each sub-sample the households were ranked in ascending order of the aggregate expenditure on all consumption goods and services in rupees[5] per person per 30 days; and the sample households (or rather the households corresponding to the estimated population) were divided into twenty *equal* fractile groups of 5 per cent each. The average expenditure, the expenditure on cereals, the price of cereals, the consumption of cereals etc., were then calculated separately for each fractile group for each of the two sub-samples and the combined sample as a whole; these estimates are shown separately for the two sub-samples and the combined sample and for rural and urban areas separately for the 8th and the 13th rounds in the accompanying Tables 1 to 8. The design of the sample surveys is given in Appendix 1; and Notes on Tables 1 to 8 in Appendix 2.

6. A graphical analysis is particularly convenient with such material as will be easily appreciated from the accompanying charts. The x-axis has been used to represent the percentiles of 'per capita consumer expenditure in rupees per 30 days'; this supplies a rough but convenient ranking order of increasing level of consumption which would also (especially in India) correspond approximately to an increasing level of household income. The y-axis represents the other variates such as aggregate consumption, expenditure on cereals, price of cereals, consumption of cereals, etc., as the case may be. The construction is simple. The value of y is plotted for each of the twenty (five-per-cent) fractile groups corresponding respectively to the position of each fractile group on the x-axis for the first sample; successive points of y are then joined by straight lines and supply the graph for sub-sample 1; graphs for sub-sample 2 and the combined sample are drawn in exactly the same way; finally the area included between the graphs for the two sub-samples is hatched to show the "error" (in the sense of FGA) associated with the combined graph. These FGA graphs, if drawn on translucent paper, can be superimposed for rapid comparison. Such comparisons can also be made by printing each set of 3 graphs (for two sub-samples and the combined sample) in a different colour. In the accompanying charts, green has been used for all graphs for the 8th round rural areas and blue for the 8th round urban areas; in the same way, red and orange have been used for the 13th round rural and urban areas respectively.

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[4] A general account of the FGA method was given in *Econometrica*, Vol. 28, 2 (April 1960) and reprinted in *Sankhyā*, Series A, Vol. 23, 1 (1961) with other articles on the subject.

[5] One rupee = 1 shilling 6 pence or 21 US cent or one new French franc approximately.

COMPARISON OF CONSUMPTION DATA

7. The great advantage of FGA is that the distribution over the whole range of per capita household expenditure or (approximately) household income can be appreciated at a glance. Also, comparisons can be made for the same fractile group (0–5, 5–10, 10–15, etc.) between rural and urban areas or directly between the 8th and the 13th rounds irrespective of the large change in prices. The area lying between the two graphs for any two combined samples shows the generalized difference or separation between the two combined samples; if this 'separation area' is appreciably greater than the two corresponding (hatched) 'error areas' then the difference or separation may be considered to be statistically significant; otherwise, not. In this method each fractile group supplies the basic statistical unit or element for comparisons. It is also possible to make comparisons for the same per capita consumer expenditure in terms of money; such comparisons however, would be meaningful only for comparisons between rural and urban areas in the same round.

8. *Aggregate consumption expenditure :* Charts (1.1)–(1.2) (and Table 1) show the aggregate expenditure on all consumer goods and services in rupees per person with increasing per capita expenditure, that is, with rising income. The expenditure in terms of rupees is appreciably higher in the 13th round in rural areas; but the change in the urban area is not significant because of the large margin of uncertainty of the graph for the 8th round urban areas.[6] The distribution of household expenditure (or of income) is highly concentrated.

9. *Expenditure on cereals :* Table 3 and Charts (1.3)–(1.4) show the expenditure on cereals[7] in rupees per person per 30 days. This has naturally increased because of the rise in the price of cereals in the 13th round; the shift was higher in rural areas.

10. *Price of cereals :* Table 4 and Charts (3.1)–(3.2) show the data for the price of cereals in rupees per seer.[8] The price clearly increases with increasing household expenditure or income in each round in both rural and urban areas. The price paid for cereals was higher in the 13th round; but the pattern of change with rising household income remained the same in the two rounds.

11. *Proportion of rice in total cereals :* The increase in the price paid per seer of cereals by higher income groups is due to the change in the composition of each unit of cereals consumed by them. The price of rice in India is usually higher than that of other cereals; the higher the proportion of rice, higher would be the total price paid per seer of cereals. Table 5 and Charts (5.1)–(5.2) show relevant data. It would be seen that the proportion of rice increases generally with rising household income. (It is necessary to point out, however, that the figures given here are all-India averages; the higher proportion of rice does not therefore necessarily refer to individual households but may, and, no doubt, is due to a large extent to rice being the staple food in certain regions of the country; with rising household income, a greater proportion of rice may also occur in the consumption in other regions as rice is usually something of a luxury in regions outside the rice area.) It is of interest to note that the increase in the proportion of rice with rising income was somewhat lower in the 13th round.

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[6] The margin of uncertainty is suspiciously large. It is quite possible that gross errors have come in either at the stage of collection or of statistical processing of the data.

[7] Cereals include rice, wheat, maize, barley, small millets, *jowar*, *bajra*, *ragi* and also processed food from such cereals (pressed rice, puffed rice, etc.).

[8] One seer = 2.057 lbs. or 0.933 kg. approximately.

12. *Price of rice in rupees per seer :* Table 6 and Charts (5.3)–(5.4) give the price of rice in rupees per seer. It would be seen that the price of rice increased very much in the 13th round. This immediately explains the somewhat lower increase in the proportion of rice with rising income in this round, which has been noted in the previous paragraph.

13. *Percentage increase in the price of cereals and of rice :* The percentage increase in the price of cereals and of rice is shown in Appendix 3 and Charts (3.3)–(3.4). The increase in the price of cereals was of the order of 40 or 50 per cent for the lower income groups. An increase in the price of cereals bears very heavily on the poorer people of India; and it is of great importance to prevent this.

14. *Consumption of cereals in seers per person per 30 days :* Table 7 and Charts (6.1)–(6.2) and (7.1)–(7.4) show the actual per capita consumption of cereals. In spite of the very large increase in price it is quite remarkable that the per capita consumption of cereals seems to have remained steady in both the 8th and the 13th rounds. The pattern of change with rising household income also remains the same in the two rounds.

15. In both rural and urban areas there is a comparatively sharp rise in consumption with rising income in the bottom 20 or 25 per cent of the population in both the rounds. In urban areas the per capita consumption tends to level off, owing most probably to the availability of other items of food. In the rural areas, on the other hand, the consumption continues to increase. It is possible that a part of the cereals is used as cattle and animal feeds.[9] In rural areas the higher income groups would be mostly well to do farmers with their own land; farmers with higher income would also usually have a larger number of cattle and the amount of cereals used as cattle feed may also be higher.

16. *Summary :* The comparison of data on consumption of cereals in the 8th and the 13th rounds reveals a coherent and reasonable picture of the situation. The general index of wholesale prices rose in the 13th round to 112 with prices in the 8th round as base (= 100); and the index of the price of cereals rose to 136 and of rice to 145. The index number of the retail price of cereals paid by the sample households rose to 136 in rural and 123 in urban areas; the rise in the retail price of rice was higher and the index number in rural areas rose to 140 and in urban areas to 129. Naturally, aggregate expenditure on all consumer goods and services as well as expenditure on cereals also increased appreciably in the 13th round. Higher prices per seer (unit quantity) of cereals were paid by households with higher income in both rural and urban areas, and the pattern (relation of price paid for cereals and household income) was same or similar in both the rounds. Such higher prices were paid because of the change in composition of unit quantity of cereals, for example, with a higher proportion of rice of higher price or of higher quality of cereals; this is further corroborated by the fact that the price of rice having risen very high, the rice component increased to a smaller extent in the 13th round with increasing household income.

17. In spite of such large changes in price, the quantity of cereals consumed remained remarkably steady in the two rounds. The quantity consumed, however, increased sharply in the bottom 20 or 25 per cent of the population in both urban and rural areas in both the rounds indicating that one-fifth of the population of India could not probably afford to eat as much cereals as they would like to. In urban areas the consumption gradually levelled off but in rural areas it continued to rise with increasing household income; this might

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[9] Due to ascertainment difficulties there is possibility of this happening in spite of instructions to the contrary.

be partly due to greater use of cereals for animal feeds by the more prosperous farmers. The pattern of change of consumption (as well as the quantity consumed) was the same or very similar in both the rounds. There is clearly income elasticity of quantity consumption of cereals throughout the whole range of household income in rural areas, and up to perhaps a third of the population in urban areas after which the consumption levels off. The pattern of income elasticity appears to be the same or very similar in both the rounds in spite of the large increase in the price of cereals; for cereals as a whole there is thus no evidence of price elasticity at the national level.[10]

18. It is worth emphasizing that the data for the two rounds were obtained with an interval of more than three years between the two rounds, from entirely different sets of villages, and different sample households, by different groups of investigators, working independently in the two inter-penetrating network of sub-samples covering the whole country, and that many of the investigators had also changed during the interval.

AGGREGATE CONSUMPTION OF CEREALS

19. It seems reasonable to assume that the per capita consumption of cereals remained steady at the level of about 17.10 seers or 15.95 kg. per 30 days with two sub-sample estimates of 17.31 and 16.90 seers respectively for the country as a whole as observed in the 13th round. It would be therefore reasonable to multiply the per capita consumption by the total population to obtain the aggregate consumption of cereals during any given period. Such estimates have been calculated for the two years 1958-59 and 1959-60 in the following way. The weighted average of the per capita consumption of cereals for rural and urban areas taken together, based on 1951 Census weights of 0.827 for rural areas and 0.173 for urban areas, is easily obtained[11] as 0.1910 ton per year for the combined sample of the 13th round, with corresponding sub-sample estimates of 0.1934 and 0.1888 ton per year.[12] The estimated population for the years 1958-59 and 1959-60 has been taken as 420 and 428 million respectively, based on the population estimate of 438 according to the Census of March, 1961. Multiplying the estimates of per capita consumption by these population figures, the aggregate consumption of cereals in 1958-59 and 1959-60 come out as 80.2 and 81.7 million tons respectively with a margin of uncertainty of about 2 million tons.

COMPARISON BETWEEN CONSUMPTION AND PRODUCTION

20. *Estimates of production:* As already mentioned, the National Sample Survey has recently started making estimates of the production of seven cereal crops (rice, wheat, barley, maize, *jowar*, *bajra* and *ragi*) for India as a whole through direct physical observation by investigators of the area sown, and by direct crop-cutting experiments for estimating the rate of yield per acre. The estimated production was 82.28 million tons of the seven cereals mentioned above in 1958-59 and 83.86 million tons in 1959-60 with a margin of uncertainty

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[10] There is, however, some evidence to suggest that the consumption of rice tended to be relatively somewhat lower in the 13th round indicating the presence of price elasticity of some kind.

[11] By multiplying the figures in seers per 30 days by the conversion factor 0.01117 to convert into ton per year.

[12] If the 1961 Census weights of .822 for rural areas and .178 for urban areas are used then these estimates would be changed to .1931, .1885, and .1908 tons per year for the two sub-samples and the combined sample respectively.

of two or three million tons.[13] These estimates of production are, however, not directly comparable with the estimates of aggregate consumption as the former included, but the latter excluded, the cereals used as seeds. It is possible from data collected by the National Sample Survey to estimate the seed requirements which came to about 7 per cent of the total production; relevant figures and references are given in Appendix 4.

21. Also, the production data excluded small millets and gram while the consumption data included these two items. From the consumption data collected in the 13th round it is found that the weighted average per capita consumption was 0.441 seers of small millets and 0.698 seers of grams per 30 days;[14] multiplied by the population figures of 420 and 428 millions respectively, the aggregate consumption would come to 2.07 and 2.11 million tons of small millets in 1958-59 and 1959-60 respectively, and 3.28 and 3.34 million tons of gram respectively in the same two years. The estimates of production, given by the Ministry of Food and Agriculture, were 2.07 and 2.01 million tons of small millets and 6.88 and 5.39 million tons of gram in these two years respectively. The agreement in the case of millets is satisfactory. Also, it is well known that only a part of the total production of gram is used for human consumption, the remaining part being used for animal feeds and other purposes ; the NSS estimates indicate that roughly half of the production of gram (as given by the Ministry of Food and Agriculture) is used for human consumption and the other half for animal feeds and other purposes. Also, excluding the consumption of millets and grams from the NSS estimates of consumption of cereals, comparable estimates of consumption of cereals would come to 79.9 and 76.3 million tons in 1958-59 and 1959-60 respectively.

22. Deduction of 7 per cent for seed requirements would reduce the NSS estimate of the production of cereals available for consumption to something like 76.52 million tons in 1958-59 and 77.99 million tons in 1959-60. It is, however, necessary to make further adjustments which are more intangible. On one side, the addition of imported cereals to the domestic production and, on the other side, losses in storage and transportation and use for other purposes such as industry or animal feeds, and changes in stocks. There are great difficulties in making precise comparisons because a good part of the crop production in one year is carried over to the next year; and also because the release of cereals out of imported stock varies a great deal from season to season. The addition to the availability of cereals in 1958-59 and 1959-60 was probably something of the order of 3.5 and 4.0 million tons respectively;[15] the total availability (after deduction of 7 per cent for seed requirements) would thus come to something like 80.0 million tons in 1958-59 and 82.0 million tons in 1959-60 against roughly 74.9 and 76.3 million tons of consumption in these two years. This leaves a balance of roughly four and a half million tons to offset losses in transport and storage, industrial use and cattle feeds, and changes in stocks.

23. It is possible to check the above calculations in a different way by accepting the over-all rate of deduction of 12½ per cent (for requirements of seeds, losses in storage and transport, animal feeds, etc.) used by the Ministry of Food and Agriculture to obtain

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[13] The size of the sample was comparatively small and covered only about 15,000 clusters of plots of land (selected with equal probability in a systematic manner with a random start), in about 2500 villages selected with equal probability in each of the three crop seasons (autumn, winter and spring). A ratio method was used for estimation. The two sub-sample estimates were 84.12 and 84.52 million tons respectively in 1958-59 and 86.25 and 86.92 million tons in 1959-60, but the estimates based on the combined samples give lower values of 82.28 and 83.86 million tons in the two years respectively ; the margin of uncertainty may thus be of the order of 2 or even 3 million tons.

[14] Or, 0.00492 ton per year of small millets and 0.00780 ton per year of grams per person.

[15] The import of cereals was 3.17, 3.81, and 5.06 million tons during the calendar years 1958, 1959 and 1960 respectively ; the agricultural crop year however extends from July to June.

the quantity of cereals available for human consumption. On this basis, the estimate of production of cereals available for consumption would be something like 72.00 million tons in 1958-59 and 73.38 million tons in 1959-60. Adding about 3.5 and 4.0 million tons of cereals which might have been released out of imported cereals, the total quantity available for human consumption would thus come to something like 75.5 million tons in 1958-59 and 77.4 million tons in 1959-60, against an aggregate consumption of 74.9 and 76.3 million tons respectively.

GENERAL APPRECIATION

24. The present comparison between aggregate consumption and aggregate production of cereals in India for 1958-59 and 1959-60 is, necessarily, somewhat rough and approximate. Firstly, there is a lag between consumption and production; a good part of the cereals produced in one crop year is consumed in subsequent years; the quantity carried over depends on the level of production, stocks and prices; it would be possible to examine the general position more adequately only when data for a number of years become available. Secondly, the release from stocks of imported cereals varies widely from month to month; a good deal of detailed information requires to be collected to estimate the actual contribution to the supply effected in any given year. Thirdly, it is extremely difficult, if not impossible, to make direct estimates of the losses which occur in transport and storage. Finally, the present NSS estimates are based on extremely small samples; the number of sample households used for the consumption survey, in each sub-sample, was less than 1200 in Round 8 and less than 1000 in Round 13 out of a total, roughly, of 85 or 90 million households in India; the number of villages covered for the production survey, in each sub-sample, in each crop season, was 1250, out of roughly 560,000 villages in the country; the margin of uncertainty (inclusive of sampling and non-sampling errors, and bias) may be of the order of two million tons or a little more.

25. It is still possible to make a general appreciation of the position keeping the above observations in mind. If deductions are made only for requirements of seeds, it has been found that there is a gap of five or five-and-a-half million tons to offset the use of cereals for animal feeds, industrial purposes, losses in transport and storage, and changes in stocks; this is not unrealistic. Also, if a deduction is made at the over-all rate of 12½ per cent of the production, according to the procedure used by the Ministry of Food and Agriculture, the difference between estimates of production and consumption of cereals is found to be of the order of one million ton; this is well within the margin of uncertainty. The National Sample Survey estimates of aggregate production and aggregate consumption of cereals in India, obtained by two entirely different and independent surveys, would thus seem to have been in reasonable agreement in 1958-59 and 1959-60.

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Appendix 1 : Sample design for consumption data

1. Data on consumer expenditure for the different rounds of the NSS were collected by the interview method from sample households selected according to usual procedures of probability sampling. Briefly, the sample design for the different rounds were as follows :—

Rural, Rounds 8 *and* 13 : The design was stratified, multi-stage, interpenetrating samples. In each stratum the first stage units of sampling were villages (rural units, selected with probability proportional to 1951 populations), and the second stage units were households (selected with equal probability).

Urban, Rounds 8 *and* 13 : The design was stratified, multi-stage, interpenetrating samples. Each big city (Calcutta, Bombay, Delhi and Madras in Round 8, and each city with a population of 3,00,000 and above as per 1951 census in Round 13) constituted a stratum; in each stratum a two-stage design was used with blocks as first stage units and households within blocks as second stage units. Remaining cities and towns were grouped on geographical considerations to constitute strata; in each stratum in both rounds, a three-stage design was used with cities or towns, blocks and households as first, second and third stage units of sampling respectively.

2. As the sample households had different probabilities of being included in the sample for purposes of estimation, it was necessary to use appropriate multipliers. For the purpose of this paper, however, sub-samples of households were selected in such a way from sample households as to become self-weighting. The number of sample villages and blocks in Tables 1 to 8 have been shown within brackets to indicate that the estimates for the items concerned are based on such sub-samples of households. The number of sample villages/blocks and number of sample households analysed separately by rounds are as follows.

	rural			urban		
	s.s.1	s.s.2	combined	s.s.1	s.s.2	combined
			sample villages/blocks			
Round 8 :	353	353	706	238	228	466
Round 13 :	462	462	924	585	583	1168
			sample households			
Round 8 :	931	938	1869	224	223	447
Round 13 :	728	738	1466	237	252	489

Appendix 2 : Notes on Tables 1 to 8

1. The reference period adopted for collection of data was a period of 30 days ending on the day preceding the day of enquiry. Since the field operations of Rounds 8 and 13 extended from July 1954 to March 1955 and from September 1957 to May 1958 respectively, the estimates, as presented, broadly refer to the period from June 1954 to March 1955 and from August 1957 to May 1958.

2. The fractile groups considered are 33 in number of which twenty are of five-per cent each (0–5, 5–10, ... and 95–100); the top 5 per cent and the bottom 5 per cent groups are broken down into five one-per-cent groups (1, 2, 3, 4, 5 and 96, 97, 98, 99 and 100); and three more groups 0–50, 50–100 and 0–100 have been added.

3. In each table, serial numbers or lines 1–33 give estimates for 33 fractile groups considered ; the number of sample villages/blocks and number of sample households are given in lines 34 and 35 of the tables. Column (2) gives the specification of the fractile groups. Columns (3)–(5), (6)–(8), (9)–(11) and (12)–(15) give estimates for rural areas Rounds 8 and 13, and urban areas Rounds 8 and 13 respectively, separately, by sub-sample 1, sub-sample 2 and combined samples.

4. Estimates of per capita consumer expenditure in Table 1 refer to expenditure on all items of consumption including services with imputed value for consumption out of homegrown stock. Table 2 gives limiting value of per capita expenditure in rupees at the upper end point of each fractile group separately for the two sub-samples and the combined sample. For example, from column (3) of Table 2 it is seen that the bottom 1, 2, 3, 4 and 5 p.c. fractile groups in Round 8, rural areas, sub-sample 1, had per capita monthly expenditure in rupees of 2.81, 3.27, 3.98, 4.15 and 4.31 respectively. Estimates of per capita expenditure on cereals given in Table 3 include imputed value of consumption out of homegrown stock. Table 8 gives expenditure on cereals expressed as a percentage of consumer expenditure and may be called Engel's ratio for cereals.

5. Cereals include rice, wheat, jowar, bajra, maize, barley, small millets, ragi and their products and a part of gram which is consumed as human food. Rice includes husked paddy and rice products like *chira*, *muri*, (pressed rice, puffed rice, etc).

Appendix 3 : Ratio of Prices 13th to 8th Rounds : Cereals and Rice

serial no.	fractile group (per cent)	rural			urban		
		s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		ratio of prices of cereals					
1	0—5	1.51	1.56	1.51	1.35	1.18	1.20
2	5—10	1.51	1.61	1.45	1.25	1.42	1.36
3	10—15	1.25	1.42	1.35	1.14	1.17	1.14
4	15—20	1.34	1.67	1.48	1.06	1.11	0.97
5	20—25	1.38	1.36	1.53	1.92	1.09	1.32
6	25—30	1.54	1.26	1.25	1.25	1.22	1.21
7	30—35	1.23	1.70	1.46	1.12	1.45	1.19
8	35—40	1.60	1.39	1.43	1.22	1.10	1.28
9	40—45	1.31	1.50	1.47	1.21	1.32	1.27
10	45—50	1.38	1.40	1.38	1.22	1.19	1.32
11	50—55	1.45	1.21	1.37	1.32	1.26	1.30
12	55—60	1.34	1.24	1.27	1.32	1.28	1.18
13	60—65	1.29	1.25	1.27	1.19	1.16	1.27
14	65—70	1.42	1.52	1.47	1.22	1.25	1.23
15	70—75	1.54	1.34	1.42	1.32	1.13	1.27
16	75—80	1.15	1.30	1.26	1.24	1.24	1.21
17	80—85	1.46	1.39	1.39	1.35	1.21	1.28
18	85—90	1.46	1.21	1.34	1.28	1.22	1.14
19	90—95	1.19	1.29	1.24	1.11	1.33	1.32
20	95—100	1.12	1.12	1.12	1.09	1.23	1.20
21	0—100	1.40	1.36	1.36	1.23	1.23	1.23
		ratio of prices of rice					
1	0—5	1.58	1.19	1.41	1.55	1.54	1.48
2	5—10	1.40	1.34	1.31	1.16	1.21	1.27
3	10—15	1.12	1.32	1.27	1.65	1.73	1.68
4	15—20	1.32	1.49	1.44	1.32	1.12	1.03
5	20—25	1.51	1.30	1.24	1.22	1.07	1.22
6	25—30	1.56	1.13	1.39	1.14	1.29	1.05
7	30—35	1.28	1.66	1.46	1.15	1.24	1.09
8	35—40	1.50	1.37	1.41	1.33	1.06	1.28
9	40—45	1.02	1.30	1.24	1.49	1.16	1.29
10	45—50	1.38	1.53	1.45	1.50	1.11	1.30
11	50—55	1.60	1.30	1.15	1.30	1.13	1.27
12	55—60	1.60	1.54	1.59	1.34	1.09	1.25
13	60—65	1.39	1.35	1.35	1.63	1.18	1.23
14	65—70	1.36	1.47	1.44	1.48	1.44	1.45
15	70—75	1.66	1.37	1.52	1.40	1.15	1.18
16	75—80	1.34	1.56	1.42	1.25	1.18	1.29
17	80—85	1.39	1.46	1.34	1.22	1.20	1.30
18	85—90	1.34	1.15	1.38	1.38	1.14	1.27
19	90—95	1.54	1.65	1.61	1.16	1.26	1.26
20	95—100	1.36	1.14	1.41	1.33	1.38	1.35
21	0—100	1.44	1.36	1.40	1.37	1.22	1.29

Appendix 4 : Seed requirements

Requirements for seeds can be estimated from data collected by NSS and some relevant figures are given below.

PRODUCTION OF CROP PER UNIT QUANTITY OF SEED USED : NSS ROUNDS 5, 6, AND 7

serial no.	crop	season	1951-52	1952-53		average
			round : 5	round : 6	round : 7	
(0)	(1)	(2)	(3)	(4)	(5)	(6)
1.	paddy	kharif	13.34	13.75	13.91	13.65
2.	wheat	rabi	7.68	7.82	7.89	7.79
3.	*jowar*	kharif	29.89	33.71	36.25	33.25
4.	,,	rabi	24.93	21.50	21.86	22.74
5.	*bajra*	kharif	30.71	36.07	31.50	32.73
6.	barley	rabi	7.93	7.79	7.50	7.73
7.	maize	kharif	40.37	34.31	33.06	35.88
8.	*ragi*	,,	22.18	19.15	27.94	23.40
9.	,,	rabi	20.03	21.18	21.59	20.91

Source : Table 2.10 and Table 1.5 of NSS Reports 32 (part I) and 32 (part II) respectively.

Using NSS figures of aggregate production of different crops, the seed rate for 1958-1959 and 1959-1960 come out as 6.83 and 6.99 per cent; it may be assumed that about 7 per cent of the total production of cereals is used as seeds.

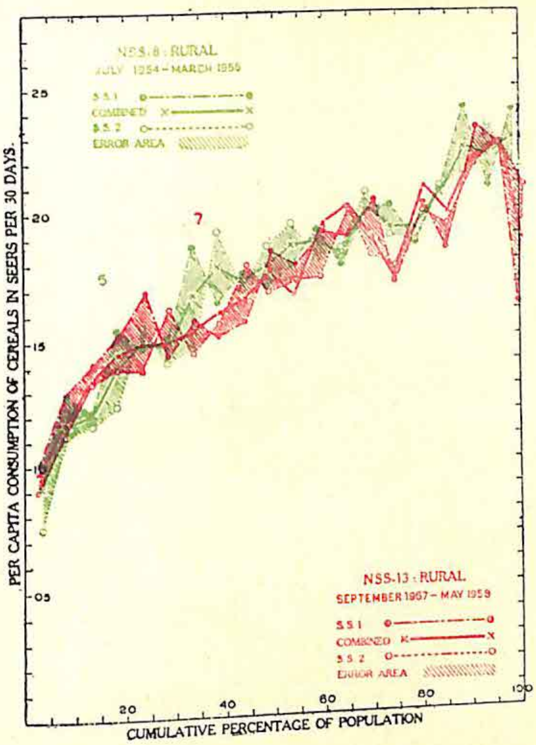

Chart 6.1. NSS-8 and 13 : All-India rural : Per capita consumption of cereals in seers per 30 days

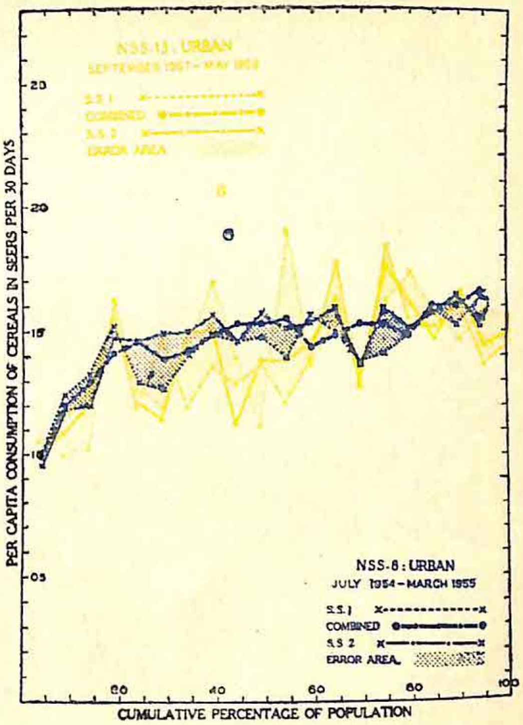

Chart 6.2. NSS-8 and 13 : All-India urban : Per capita consumption of cereals in seers per 30 days

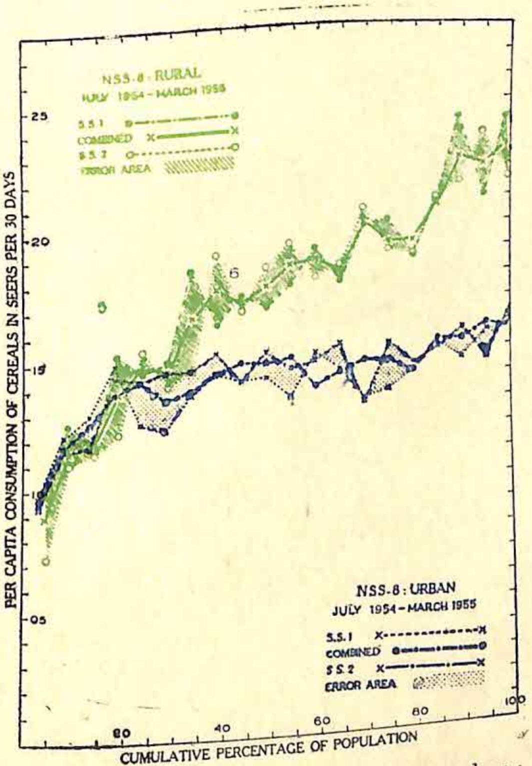

Chart 7.1. NSS-8 : All-India, rural and urban : Per capita consumption of cereals in seers per 30 days

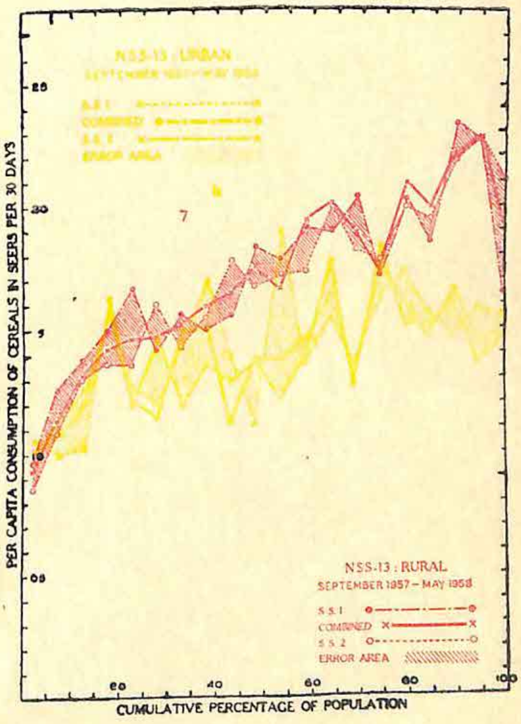

Chart 7.2. NSS-13 : All-India, rural and urban : Per capita consumption of cereals in seers per 30 days

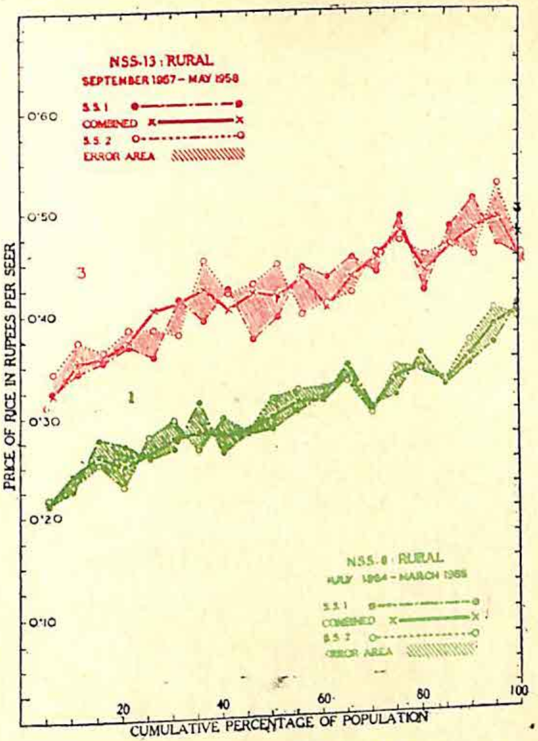

Chart 3.1. NSS–8 and 13 : All-India rural : Average price of cereals in rupees per seer

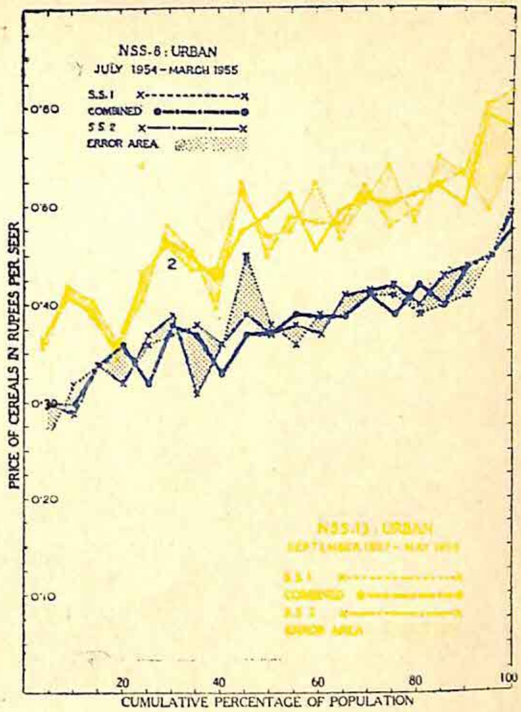

Chart 3.2. NSS–8 and 13 : All-India urban : Average price of cereals in rupees per seer

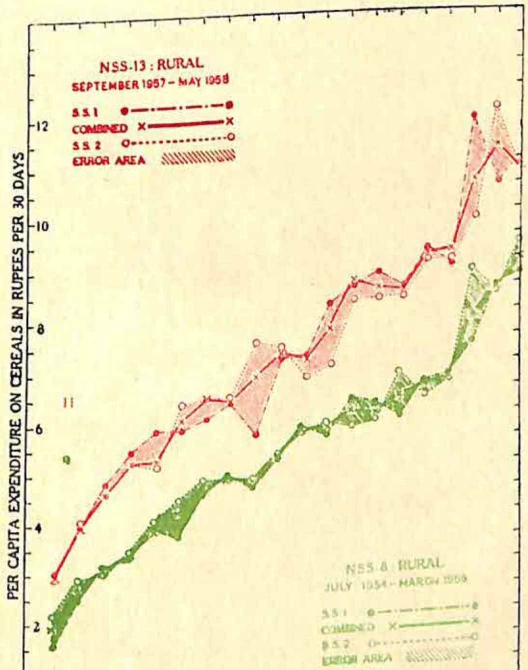

Chart 1.3. NSS–8 and 13 : All-India rural : Per capita expenditure on cereals in rupees per 30 days

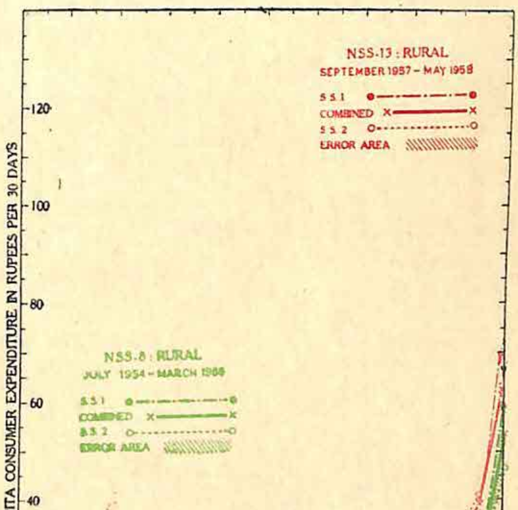

Chart 1.1. NSS–8 and 13 : All-India rural : Per capita consumer expenditure in rupees per 30 days

NATIONAL SAMPLE SURVEY : Round 8 : July 1954–March 1955 and Round 13 : September 1957–May 1958

TABLE 1 : AVERAGE PER CAPITA CONSUMER EXPENDITURE IN RUPEES PER 30 DAYS : ALL-INDIA, RURAL AND URBAN

serial no.	fractile group (per cent)	average expenditure in each fractile group											
		rural						urban					
		round 8			round 13			round 8			round 13		
		s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	1	2.41	2.97	2.74	3.72	3.58	3.34	4.00	4.24	4.23	4.28	5.63	5.23
2	2	3.12	3.59	3.48	5.09	4.66	5.09	4.83	5.31	5.09	6.61	6.08	6.39
3	3	3.76	4.05	3.91	5.74	5.13	5.39	5.52	5.57	5.53	6.78	6.90	6.79
4	4	4.09	4.48	4.18	6.09	5.56	5.78	5.89	6.18	6.04	6.98	7.28	7.06
5	5	4.22	4.72	4.70	6.13	5.82	6.09	6.42	6.80	6.54	7.48	7.46	7.53
6	0— 5	3.54	4.00	3.80	5.36	4.92	5.14	4.93	5.59	5.48	6.53	6.53	6.58
7	5—10	4.88	5.29	5.16	7.25	6.67	6.95	7.47	7.76	7.61	8.73	8.87	8.76
8	10—15	5.90	6.18	6.04	8.49	8.13	8.29	8.80	9.25	8.96	10.17	10.29	10.26
9	15—20	6.60	6.93	6.79	9.61	8.87	9.12	9.79	10.68	10.22	11.28	11.50	11.46
10	20—25	7.38	7.84	7.61	10.57	9.71	10.11	11.15	12.01	11.48	12.58	12.67	12.67
11	25—30	8.07	8.65	8.37	11.43	10.73	11.14	12.08	13.65	12.64	13.69	14.01	13.89
12	30—35	8.77	9.25	9.02	12.22	11.62	12.01	13.29	14.60	13.74	14.83	15.40	16.26
13	35—40	9.76	9.78	9.72	13.45	12.46	12.86	14.21	15.78	14.81	16.06	16.71	16.44
14	40—45	10.50	10.44	10.50	13.96	13.53	14.02	15.27	17.72	16.08	17.15	18.27	17.85
15	45—50	11.32	11.34	11.30	14.98	13.97	14.88	16.72	19.41	17.80	18.57	19.82	18.92
16	50—55	12.15	12.18	12.17	16.06	15.59	15.94	18.25	20.80	19.30	20.06	21.45	20.85
17	55—60	13.07	13.12	13.09	17.66	16.79	17.49	19.75	22.44	20.92	21.38	22.98	23.47
18	60—65	14.15	14.47	14.35	18.49	18.37	18.83	21.81	25.49	22.64	23.24	24.75	24.51
19	65—70	15.49	15.77	15.52	19.21	19.47	18.81	23.55	28.14	25.08	25.68	27.16	26.71
20	70—75	16.89	17.52	17.34	21.09	21.39	21.37	25.70	31.74	27.63	28.18	29.34	28.91
21	75—80	18.54	19.55	19.00	22.87	23.63	23.94	28.69	35.29	31.40	30.87	32.78	32.11
22	80—85	20.84	21.98	21.44	25.83	26.62	26.37	33.81	39.79	35.94	34.74	38.33	37.35
23	85—90	24.00	25.62	24.64	28.39	29.52	29.00	41.32	47.30	42.07	40.10	44.92	43.85
24	90—95	30.46	30.12	30.16	34.10	38.59	36.70	49.79	59.43	53.46	50.63	56.16	55.93
25	95—100	62.42	47.88	54.15	66.93	58.03	59.81	80.60	117.00	100.11	81.35	93.87	91.75
26	96	37.35	34.79	34.47	40.37	41.46	41.70	57.26	72.68	65.70	62.75	63.39	62.71
27	97	41.80	37.43	38.51	45.39	44.71	45.84	62.62	92.92	71.46	70.46	65.98	70.10
28	98	49.79	39.13	45.41	52.35	49.22	53.09	69.51	125.51	84.96	79.15	72.14	79.60
29	99	59.07	50.45	53.32	61.58	62.17	75.83	79.06	141.23	118.71	97.21	92.61	91.01
30	100	118.38	77.46	93.62	113.82	114.69	124.69	133.18	154.61	158.83	161.12	127.08	141.24
31	0—50	7.69	7.98	7.83	10.74	10.06	10.46	12.11	12.66	12.31	13.09	13.30	13.21
32	50—100	22.84	21.95	22.09	25.95	26.63	26.45	33.38	42.72	37.84	36.52	38.55	37.66
33	0—100	14.93	14.98	14.96	18.31	18.33	18.32	22.44	27.69	25.04	24.63	26.00	25.36
no. of s. villages/blocks		353	353	706	(462)	(462)	(924)	(238)	(228)	(466)	(585)	(583)	(1168)
no. of s. households		931	938	1869	728	738	1466	224	223	447	237	252	489

NATIONAL SAMPLE SURVEY : Round 8 : July 1954–March 1955 and Round 13 : September 1957–May 1958

TABLE 2 : LIMITING VALUE IN RUPEES AT UPPER END IN EACH FRACTILE GROUP : ALL-INDIA, RURAL AND URBAN

serial no.	fractile group (per cent)	limiting value in rupees at upper end in each fractile group											
		rural						urban					
		round 8			round 13			round 8			round 13		
		s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	1	2.81	3.21	2.96	4.45	4.23	4.50	4.71	4.93	4.73	5.92	5.90	5.91
2	2	3.27	3.94	3.77	5.41	4.91	5.07	5.14	5.37	5.35	6.72	6.09	6.62
3	3	3.98	4.18	4.04	5.94	5.27	5.65	5.74	5.97	5.74	6.86	6.82	6.94
4	4	4.15	4.55	4.30	6.18	5.85	6.05	6.22	6.40	6.34	7.22	7.05	7.28
5	5	4.31	4.81	4.57	6.50	6.11	6.32	6.55	7.00	6.67	7.67	7.77	7.77
6	0— 5	4.31	4.81	4.57	6.50	6.11	6.32	6.55	7.00	6.67	7.67	7.77	7.77
7	5—10	5.48	5.89	5.70	7.90	7.53	7.75	8.14	8.52	8.30	9.64	9.69	9.67
8	10—15	6.25	6.56	6.40	9.03	8.52	8.75	9.37	10.15	9.59	10.70	10.93	10.79
9	15—20	7.01	7.39	7.18	10.05	9.34	9.70	10.22	11.24	10.82	11.88	12.08	12.07
10	20—25	7.78	8.33	8.02	11.04	10.11	10.65	11.76	12.66	12.15	13.30	13.36	13.36
11	25—30	8.26	8.93	8.67	11.70	11.15	11.63	12.68	14.02	13.29	14.16	14.65	14.40
12	30—35	9.21	9.52	9.39	12.78	11.99	12.44	13.73	15.02	14.24	15.33	16.01	15.65
13	35—40	10.15	10.18	10.17	13.43	12.87	13.27	14.65	16.91	15.30	16.70	17.66	17.05
14	40—45	10.91	10.80	10.86	14.38	14.12	14.37	15.87	18.76	17.02	18.15	18.69	18.35
15	45—50	11.74	11.75	11.74	15.28	15.07	15.24	17.42	20.17	18.50	19.07	20.63	19.83
16	50—55	12.50	12.56	12.53	16.60	16.17	16.43	18.78	21.53	20.06	20.80	22.17	21.57
17	55—60	13.73	13.70	13.72	17.68	17.33	17.55	20.91	23.79	21.73	22.50	24.03	23.40
18	60—65	14.66	14.95	14.80	18.98	18.83	18.95	22.50	26.39	23.71	24.22	25.99	25.54
19	65—70	16.23	16.69	16.42	20.35	20.21	20.37	24.45	29.65	26.08	26.82	28.33	27.80
20	70—75	17.45	18.37	17.89	22.26	22.53	22.47	27.13	38.22	29.16	28.88	30.99	30.11
21	75—80	19.72	20.83	20.22	24.49	24.70	24.64	30.92	37.20	33.48	32.29	35.65	34.77
22	80—85	21.92	23.52	22.75	26.69	27.54	27.27	36.78	42.06	38.59	37.24	40.76	40.18
23	85—90	26.79	28.03	27.55	31.83	32.15	32.44	46.71	53.61	46.65	44.56	48.91	48.73
24	90—95	35.11	33.25	34.13	38.45	40.34	40.34	52.97	70.29	63.49	57.80	62.71	63.63
25	95—100	239.25	112.96	239.25	305.55	295.54	305.55	525.07	333.92	525.07	279.02	307.69	307.69
26	96	38.44	36.27	36.66	42.43	42.38	43.39	59.55	76.76	68.41	69.16	63.39	67.72
27	97	46.46	38.02	40.93	48.96	46.13	48.96	65.05	107.45	75.08	74.15	68.48	73.47
28	98	52.66	41.29	48.24	56.06	56.19	58.58	72.31	127.18	101.34	86.48	78.08	88.34
29	99	64.75	60.33	61.35	84.02	84.69	95.92	88.27	150.13	129.82	105.86	114.44	106.69
30	100	239.25	112.96	239.25	305.55	295.54	305.55	525.07	333.92	525.07	279.02	307.69	307.69
31	0—50	11.74	11.75	11.74	15.28	15.07	15.24	17.42	20.17	18.50	19.07	20.63	19.83
32	50—100	239.25	112.96	239.25	305.55	295.54	305.55	525.07	333.92	525.07	279.02	307.69	307.69
33	0—100	239.25	112.96	239.25	305.55	295.54	305.55	525.07	333.92	525.07	279.02	307.69	307.69
no. of s. villages/blocks		353	353	706	(462)	(462)	(924)	(238)	(228)	(466)	(585)	(583)	(1168)
no. of s. households		931	938	1869	728	738	1466	224	223	447	237	252	489

NATIONAL SAMPLE SURVEY : Round 8 : July 1954–March 1955 and Round 13 : September 1957–May 1958

TABLE 3 : AVERAGE PER CAPITA EXPENDITURE ON CEREALS IN RUPEES PER 30 DAYS : ALL-INDIA, RURAL AND URBAN

serial no.	fractile group (per cent)	average expenditure in each fractile group											
		rural						urban					
		round 8			round 13			round 8			round 13		
		s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	1	0.68	1.65	1.20	1.65	1.66	1.59	2.32	2.51	2.04	1.53	3.85	3.16
2	2	1.60	1.94	1.86	3.13	2.50	2.88	2.23	3.14	3.04	4.63	3.13	3.74
3	3	2.05	2.23	1.91	3.40	3.13	3.03	2.75	2.23	2.44	3.63	2.65	3.48
4	4	1.28	2.59	2.03	4.03	3.63	3.75	2.97	3.48	3.33	4.25	4.08	3.66
5	5	2.14	2.47	2.52	3.43	3.81	3.84	3.35	2.93	3.39	1.57	4.09	3.11
6	0— 5	1.58	2.20	1.91	3.13	2.95	3.03	2.43	2.86	2.85	3.74	3.50	3.58
7	5—10	2.50	2.91	2.75	4.03	4.07	4.00	3.68	3.52	3.48	3.90	4.65	4.33
8	10—15	3.18	3.03	3.11	4.86	4.72	4.69	3.92	4.37	4.21	3.90	4.95	4.55
9	15—20	3.32	3.49	3.42	5.48	5.27	5.31	4.59	4.59	4.81	5.49	5.54	5.49
10	20—25	3.93	4.06	3.87	5.91	5.25	5.29	5.05	4.56	4.65	5.35	4.68	5.05
11	25—30	3.72	4.46	4.22	5.91	6.39	6.07	4.93	4.73	5.12	5.35	6.83	6.12
12	30—35	4.56	4.87	4.70	6.10	6.54	6.47	5.52	4.51	5.00	6.13	5.26	6.55
13	35—40	4.99	4.85	4.91	6.35	6.48	6.41	5.26	5.50	4.89	7.21	5.26	6.27
14	40—45	4.69	4.88	4.81	5.78	7.57	6.91	5.29	5.50	5.43	6.96	6.59	5.18
15	45—50	5.23	5.31	5.25	7.24	7.47	7.31	5.38	5.26	5.73	5.07	6.01	6.61
16	50—55	5.85	5.73	5.78	7.29	6.86	7.22	5.69	5.11	5.50	8.90	5.82	6.88
17	55—60	5.68	5.93	5.81	8.29	7.07	7.78	5.70	6.14	5.37	6.99	6.60	6.48
18	60—65	6.37	5.83	6.11	8.62	8.33	8.70	5.66	5.89	5.64	7.06	8.37	7.89
19	65—70	6.25	5.92	6.06	8.89	8.36	8.57	6.84	5.36	6.04	6.68	6.48	6.50
20	70—75	5.96	6.88	6.38	8.59	8.37	8.41	5.70	5.22	5.71	8.60	8.66	8.70
21	75—80	6.63	6.34	6.58	9.30	9.07	9.23	6.03	6.49	5.58	8.20	7.40	8.07
22	80—85	6.74	6.61	6.70	8.98	9.04	9.27	5.80	6.44	6.27	8.45	7.78	7.49
23	85—90	7.35	8.80	7.89	11.94	9.90	10.68	6.48	6.29	6.58	7.66	8.41	8.15
24	90—95	8.48	8.31	8.43	10.53	12.02	11.27	6.45	7.00	7.11	7.75	8.08	8.44
25	95—100	8.68	9.31	8.98	11.12	10.50	10.72	8.38	7.74	7.38	8.35	8.81	8.51
26	96	9.93	8.94	8.81	10.08	9.39	9.71	9.54	5.97	6.28	9.26	10.06	8.55
27	97	7.49	7.10	9.00	11.43	12.31	11.68	6.79	7.34	6.27	9.27	8.14	8.41
28	98	9.10	10.75	8.56	9.66	12.04	9.79	6.20	7.79	7.66	6.68	6.03	7.64
29	99	8.56	9.39	9.02	9.50	9.96	10.22	6.88	9.63	7.52	7.97	7.57	6.94
30	100	8.25	10.51	9.31	8.75	10.65	9.39	9.87	7.85	9.16	4.45	12.39	11.33
31	0—50	3.79	4.00	3.89	5.48	5.66	5.60	4.59	4.50	4.50	5.25	5.31	5.32
32	50—100	6.84	6.98	6.69	9.43	9.15	9.30	6.03	6.17	6.17	7.89	7.62	7.71
33	0—100	5.09	5.49	5.29	7.45	7.40	7.43	5.31	5.35	5.33	6.55	6.47	6.51
no. of s. villages/blocks		353	353	706	(462)	(462)	(924)	(238)	(228)	(466)	(585)	(583)	(1168)
no. of s. households		931	938	1869	728	738	1466	224	223	447	237	252	489

NATIONAL SAMPLE SURVEY : Round 8 : July 1954—March 1955 and Round 13 : September 1957—May 1958

TABLE 4 : AVERAGE PRICE OF CEREALS IN RUPEES PER SEER : ALL-INDIA, RURAL AND URBAN

serial no.	fractile group (per cent)	average price in each fractile group											
		rural						urban					
		round 8			round 13			round 8			round 13		
		s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	1	0.219	0.217	0.204	0.263	0.328	0.283	0.420	0.228	0.319	0.378	0.336	0.341
2	2	0.166	0.184	0.191	0.344	0.259	0.306	0.299	0.360	0.267	0.617	0.397	0.429
3	3	0.225	0.206	0.204	0.277	0.431	0.284	0.257	0.417	0.317	0.398	0.266	0.384
4	4	0.201	0.198	0.214	0.293	0.308	0.310	0.258	0.278	0.315	0.298	0.326	0.298
5	5	0.234	0.275	0.214	0.406	0.374	0.363	0.317	0.367	0.297	0.440	0.571	0.540
6	0—5	0.208	0.213	0.207	0.314	0.332	0.312	0.268	0.299	0.300	0.363	0.354	0.360
7	5—10	0.221	0.226	0.235	0.333	0.363	0.341	0.323	0.293	0.301	0.403	0.415	0.410
8	10—15	0.273	0.248	0.257	0.342	0.352	0.347	0.342	0.341	0.338	0.391	0.400	0.386
9	15—20	0.266	0.225	0.245	0.357	0.375	0.363	0.323	0.323	0.364	0.343	0.360	0.354
10	20—25	0.252	0.275	0.258	0.347	0.375	0.394	0.359	0.367	0.321	0.430	0.401	0.423
11	25—30	0.263	0.292	0.320	0.404	0.369	0.401	0.367	0.391	0.383	0.457	0.476	0.462
12	30—35	0.310	0.261	0.279	0.382	0.444	0.414	0.385	0.310	0.373	0.432	0.451	0.445
13	35—40	0.258	0.293	0.275	0.412	0.407	0.394	0.355	0.360	0.332	0.433	0.395	0.424
14	40—45	0.276	0.277	0.278	0.362	0.416	0.409	0.454	0.394	0.369	0.509	0.521	0.470
15	45—50	0.280	0.311	0.294	0.385	0.436	0.405	0.383	0.374	0.370	0.466	0.445	0.487
16	50—55	0.299	0.320	0.309	0.434	0.387	0.422	0.357	0.385	0.390	0.472	0.487	0.508
17	55—60	0.314	0.320	0.309	0.422	0.398	0.392	0.394	0.374	0.386	0.520	0.480	0.454
18	60—65	0.344	0.326	0.333	0.443	0.406	0.423	0.390	0.413	0.388	0.464	0.479	0.491
19	65—70	0.301	0.295	0.301	0.426	0.447	0.443	0.411	0.415	0.409	0.500	0.518	0.504
20	70—75	0.314	0.341	0.330	0.484	0.457	0.469	0.407	0.420	0.392	0.538	0.475	0.499
21	75—80	0.354	0.339	0.340	0.408	0.442	0.429	0.387	0.398	0.421	0.480	0.493	0.508
22	80—85	0.322	0.327	0.325	0.471	0.453	0.452	0.404	0.427	0.405	0.546	0.518	0.517
23	85—90	0.342	0.365	0.351	0.500	0.442	0.470	0.414	0.435	0.436	0.529	0.530	0.498
24	90—95	0.363	0.399	0.381	0.454	0.515	0.483	0.446	0.450	0.447	0.493	0.599	0.589
25	95—100	0.403	0.388	0.392	0.438	0.448	0.436	0.500	0.499	0.482	0.543	0.612	0.576
26	96	0.410	0.393	0.383	0.408	0.431	0.421	0.464	0.467	0.470	0.571	0.437	0.530
27	97	0.370	0.344	0.381	0.443	0.537	0.482	0.455	0.545	0.460	0.521	0.425	0.547
28	98	0.417	0.396	0.379	0.470	0.475	0.482	0.445	0.511	0.494	0.534	0.608	0.581
29	99	0.358	0.356	0.376	0.397	0.390	0.405	0.437	0.462	0.527	0.498	0.685	0.595
30	100	0.453	0.442	0.436	0.514	0.493	0.482	0.537	0.530	0.490	0.611	0.654	0.650
31	0—50	0.259	0.266	0.265	0.366	0.394	0.381	0.346	0.347	0.341	0.423	0.422	0.423
32	50—100	0.321	0.342	0.330	0.447	0.440	0.446	0.406	0.422	0.419	0.508	0.518	0.514
33	0—100	0.295	0.309	0.302	0.413	0.421	0.418	0.381	0.386	0.382	0.470	0.473	0.472
no. of s. villages/blocks		353	353	706	(462)	(462)	(924)	(238)	(228)	(466)	(585)	(583)	(1168)
no. of s. households		931	938	1869	728	738	1466	224	223	447	237	252	489

NATIONAL SAMPLE SURVEY : Round 8 : July 1954–March 1955 and Round 13 : September 1957–May 1958

TABLE 5: PERCENTAGE OF RICE TO CEREALS (QUANTITY): ALL-INDIA, RURAL AND URBAN

serial no.	fractile group (per cent)	percentage of rice to cereals (quantity)											
		rural						urban					
		round 8			round 13			round 8			round 13		
		s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	1	28.62	22.13	20.88	18.31	15.61	17.08	0.00	26.25	12.36	38.31	1.38	6.16
2	2	12.17	11.88	18.69	24.42	47.82	33.51	1.48	99.20	41.35	83.33	7.94	32.28
3	3	34.98	26.18	23.88	7.89	60.19	26.50	22.57	0.00	40.83	71.66	4.55	64.81
4	4	20.44	16.23	32.31	20.19	15.86	18.83	17.29	8.55	42.01	0.93	0.00	1.84
5	5	48.96	26.14	25.23	49.88	25.78	35.35	51.14	54.19	9.81	60.00	100.00	90.36
6	0— 5	30.00	19.92	24.89	22.65	31.83	26.80	18.72	44.77	28.66	33.14	15.86	24.14
7	5—10	30.65	25.47	28.12	27.71	32.38	30.41	30.29	30.75	36.33	39.15	40.71	41.15
8	10—15	30.64	31.45	30.50	34.32	30.28	29.88	36.21	54.84	42.46	20.16	20.50	17.73
9	15—20	31.62	33.61	33.31	32.99	34.69	33.13	73.37	51.63	71.37	7.31	28.35	22.67
10	20—25	39.01	40.81	39.68	34.37	29.52	39.51	65.55	57.29	53.82	40.31	40.65	38.36
11	25—30	43.04	40.84	44.95	36.82	42.41	41.81	35.69	50.45	43.04	71.51	62.72	59.29
12	30—35	55.99	48.18	47.71	43.51	54.48	47.76	15.11	44.41	36.54	25.79	50.94	59.89
13	35—40	39.31	46.52	43.65	55.87	45.25	40.77	39.14	77.44	44.20	52.67	39.59	49.09
14	40—45	46.49	34.22	40.49	41.55	42.22	49.11	56.36	60.56	66.62	77.56	69.17	53.13
15	45—50	44.84	55.88	49.83	44.01	41.81	40.16	51.29	44.82	56.40	43.75	36.71	57.92
16	50—55	58.67	57.10	57.88	34.83	38.78	43.31	68.53	39.34	62.52	52.41	53.94	52.99
17	55—60	54.92	63.10	57.45	41.57	28.87	27.74	58.66	54.84	50.48	71.00	50.87	44.47
18	60—65	73.50	45.39	59.12	51.05	42.11	47.69	67.28	58.44	62.35	35.72	81.64	69.15
19	65—70	44.41	44.84	45.21	41.42	47.46	46.85	80.15	66.29	59.11	47.79	51.36	49.88
20	70—75	55.43	64.77	59.32	44.70	45.24	43.89	62.14	44.10	54.45	72.98	35.89	52.67
21	75—80	60.41	51.50	56.75	46.97	33.98	40.75	33.22	62.66	42.63	49.65	83.07	60.52
22	80—85	54.26	45.17	50.05	51.47	47.17	47.78	33.60	60.45	52.88	45.60	62.03	58.45
23	85—90	52.65	67.36	58.36	60.90	45.33	53.17	77.55	47.23	59.04	51.48	50.19	44.50
24	90—95	56.42	69.12	66.40	41.18	55.63	49.12	42.39	49.00	61.31	46.56	72.55	69.36
25	95—100	62.48	58.12	59.87	27.14	45.16	43.42	60.22	57.47	44.95	52.11	45.07	46.89
26	96	75.50	55.30	61.77	36.40	24.36	22.50	60.81	98.44	37.12	63.65	0.00	51.00
27	97	57.19	64.44	69.12	55.91	52.00	62.52	83.57	65.45	45.74	49.00	49.65	61.87
28	98	67.14	71.88	52.90	76.48	69.14	76.20	39.83	20.66	55.33	33.60	57.57	37.88
29	99	50.92	28.18	48.96	32.53	35.05	28.79	59.47	85.46	30.59	40.38	38.76	39.32
30	100	37.84	66.34	61.53	32.02	47.27	47.33	44.86	37.36	69.98	40.38	43.81	43.48
31	0—50	40.42	39.00	39.65	38.50	39.26	38.73	43.40	51.83	48.82	40.45	41.40	42.59
32	50—100	57.26	57.70	57.09	45.73	41.43	44.25	57.02	53.15	55.29	52.03	60.30	55.67
33	0—100	49.88	49.72	48.65	41.62	41.01	41.32	51.87	52.67	52.22	46.77	51.65	49.38
no. of s. villages/blocks		353	353	706	(462)	(462)	(924)	(238)	(228)	(466)	(585)	(583)	(1168)
no. of s. households		931	938	1869	728	738	1466	224	223	447	237	252	489

NATIONAL SAMPLE SURVEY : Round 8 : July 1954–March 1955 and Round 13 : September 1957–May 1958

TABLE 6 : AVERAGE PRICE OF RICE IN RUPEES PER SEER : ALL-INDIA, RURAL AND URBAN

serial no.	fractile group (per cent)	average price in each fractile group											
		rural						urban					
		round 8			round 13			round 8			round 13		
		s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	1	0.326	0.345	0.325	0.513	0.418	0.469	—	0.515	0.393	0.503	0.688	0.544
2	2	0.282	0.464	0.330	0.423	0.325	0.403	0.500	0.359	0.357	0.650	0.492	0.637
3	3	0.279	0.327	0.323	0.485	0.430	0.456	0.206	—	0.320	0.413	0.600	0.412
4	4	0.277	0.335	0.301	0.385	0.786	0.434	0.314	0.250	0.384	0.615	—	0.609
5	5	0.291	0.434	0.316	0.477	0.449	0.457	0.402	0.404	0.352	0.500	0.571	0.560
6	0— 5	0.285	0.374	0.313	9.451	0.445	0.442	0.318	0.371	0.353	0.493	0.573	0.521
7	5—10	0.306	0.341	0.337	0.427	0.457	0.440	0.412	0.412	0.383	0.478	0.498	0.485
8	10—15	0.378	0.364	0.369	0.423	0.480	0.470	0.364	0.323	0.344	0.602	0.559	0.578
9	15—20	0.363	0.304	0.333	0.479	0.454	0.479	0.381	0.363	0.395	0.504	0.406	0.406
10	20—25	0.322	0.357	0.332	0.485	0.465	0.413	0.424	0.428	0.418	0.519	0.456	0.511
11	25—30	0.328	0.365	0.353	0.512	0.414	0.490	0.422	0.416	0.494	0.483	0.538	0.520
12	30—35	0.358	0.307	0.333	0.458	0.511	0.485	0.491	0.427	0.408	0.566	0.530	0.444
13	35—40	0.315	0.359	0.335	0.473	0.493	0.472	0.382	0.454	0.398	0.508	0.480	0.510
14	40—45	0.307	0.395	0.349	0.312	0.514	0.434	0.364	0.476	0.423	0.541	0.554	0.545
15	45—50	0.347	0.362	0.354	0.478	0.554	0.515	0.413	0.471	0.437	0.618	0.522	0.570
16	50—55	0.351	0.373	0.361	0.563	0.484	0.421	9.424	0.498	0.452	0.526	0.564	0.575
17	55—60	0.339	0.351	0.347	0.542	0.540	0.552	0.422	0.458	0.426	0.566	0.501	0.531
18	60—65	0.381	0.392	0.386	0.528	0.530	0.521	0.362	0.418	0.422	0.589	0.493	0.521
19	65—70	0.407	0.358	0.382	0.552	0.528	0.550	0.408	0.422	0.411	0.604	0.606	0.594
20	70—75	0.373	0.384	0.379	0.620	0.525	0.576	0.419	0.522	0.496	0.587	0.602	0.584
21	75—80	0.391	0.379	0.386	0.522	0.592	0.548	0.472	0.428	0.451	0.588	0.507	0.584
22	80—85	0.384	0.394	0.402	0.532	0.576	0.538	0.507	0.468	0.438	0.618	0.563	0.570
23	85—90	0.402	0.402	0.393	0.540	0.464	0.541	0.436	0.543	0.484	0.603	0.621	0.615
24	90—95	0.397	0.343	0.366	0.612	0.567	0.589	0.552	0.486	0.498	0.641	0.613	0.625
25	95—100	0.431	0.424	0.426	0.585	0.483	0.603	0.474	0.498	0.497	0.632	0.685	0.672
26	96	0.429	0.409	0.408	0.737	0.443	0.536	0.462	0.428	0.413	0.622	—	0.708
27	97	0.401	0.376	0.410	0.458	0.456	0.480	0.417	0.496	0.471	0.607	0.496	0.606
28	98	0.450	0.425	0.423	0.616	0.527	0.554	0.567	0.546	0.505	0.757	0.679	0.751
29	99	0.394	0.471	0.435	0.519	0.437	0.573	0.427	0.463	0.473	0.651	0.785	0.719
30	100	0.478	0.456	0.458	0.714	0.524	0.576	0.557	0.662	0.524	0.741	0.669	0.772
31	0—50	0.333	0.351	0.342	0.450	0.488	0.502	0.399	0.420	0.415	0.530	0.510	0.509
32	50—100	0.389	0.388	0.388	0.557	0.529	0.524	0.437	0.468	0.454	0.603	0.566	0.583
33	0—100	0.369	0.376	0.373	0.531	0.512	0.521	0.420	0.447	0.431	0.575	0.545	0.554
no. of s. villages/blocks		353	353	706	(462)	(462)	(924)	(238)	(228)	(466)	(585)	(583)	(1168)
no. of s. households		931	938	1869	728	738	1466	224	223	447	237	252	489

NATIONAL SAMPLE SURVEY : Round 8 : July 1954–March 1955 and Round 13 : September 1957–May 1958

TABLE 7 : AVERAGE PER CAPITA CONSUMPTION OF CEREALS IN SEERS PER 30 DAYS : ALL-INDIA, RURAL AND URBAN

serial no.	fractile group (per cent)	average consumption in each fractile group											
		rural						urban					
		round 8			round 13			round 8			round 13		
		s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	1	3.11	7.59	5.89	6.28	5.06	5.62	5.52	11.01	6.39	4.05	11.47	9.27
2	2	9.61	10.52	9.74	9.09	9.64	9.40	7.42	8.73	11.39	7.50	7.88	8.71
3	3	9.12	10.85	9.34	12.29	7.26	10.68	10.72	5.35	7.69	9.13	9.95	9.06
4	4	6.36	13.06	9.47	13.77	11.79	12.11	10.41	12.52	10.57	14.27	12.50	12.26
5	5	9.13	8.99	11.77	8.44	10.20	10.58	10.56	7.99	11.42	3.57	7.16	5.76
6	0— 5	7.60	10.34	9.24	9.98	8.89	9.70	9.08	9.56	9.49	10.29	9.90	9.94
7	5—10	11.29	12.88	11.70	12.09	11.21	11.74	11.39	12.00	11.56	9.68	11.20	10.57
8	10—15	11.65	12.24	12.10	14.19	13.41	13.52	11.46	12.82	12.46	9.97	12.39	11.79
9	15—20	12.46	15.53	13.96	15.37	14.04	14.61	14.23	14.68	13.62	16.00	15.38	15.52
10	20—25	15.61	14.75	15.02	17.05	13.99	14.96	14.08	12.41	14.01	12.43	11.66	11.94
11	25—30	14.15	15.28	14.75	14.64	16.41	15.14	14.40	12.09	13.29	11.69	14.35	13.24
12	30—35	14.70	18.68	16.83	15.95	14.74	15.64	14.43	13.60	13.60	14.19	11.66	14.71
13	35—40	19.31	16.53	17.87	15.41	15.91	16.26	15.05	14.32	14.32	16.67	13.31	14.79
14	40—45	16.97	17.59	17.29	15.98	18.19	16.88	14.00	13.97	14.74	13.68	12.65	11.01
15	45—50	18.69	17.09	17.88	18.79	17.15	18.03	15.11	14.08	14.68	10.88	13.51	13.57
16	50—55	19.55	17.88	18.71	18.26	17.74	17.11	14.52	13.27	14.86	18.85	11.94	13.55
17	55—60	18.10	19.51	18.80	19.63	17.77	19.86	14.66	14.97	13.67	13.45	13.74	14.28
18	60—65	18.49	17.91	18.32	19.45	20.52	20.59	15.34	14.27	14.21	15.20	17.48	16.08
19	65—70	20.76	20.07	20.15	20.86	18.71	19.36	12.95	13.11	14.60	13.37	12.50	12.89
20	70—75	18.98	20.18	19.32	17.74	18.30	17.93	15.24	13.38	14.62	15.99	18.25	17.43
21	75—80	18.74	18.68	19.33	20.78	20.54	21.52	14.42	14.06	14.05	17.10	15.00	15.88
22	80—85	20.90	20.70	20.60	19.06	19.97	20.53	14.97	15.07	15.30	15.46	15.01	14.49
23	85—90	21.48	24.08	22.50	23.86	22.39	22.70	15.68	14.46	15.26	14.49	15.88	16.36
24	90—95	23.38	20.85	22.11	23.21	23.33	23.29	14.39	15.57	15.92	15.72	13.48	14.33
25	95—100	21.56	24.00	22.90	25.39	23.43	24.57	16.54	15.52	15.55	15.37	14.40	14.78
26	96	24.20	22.73	22.99	24.70	21.80	23.08	20.54	12.78	14.17	16.21	23.00	16.12
27	97	20.23	20.64	23.61	25.79	22.92	24.25	14.97	13.46	13.51	17.78	19.14	15.38
28	98	21.82	27.13	22.61	20.54	25.34	20.29	13.91	15.25	16.23	12.50	9.91	13.14
29	99	23.88	26.38	23.98	23.92	25.51	25.22	15.74	20.84	13.86	15.99	11.05	11.67
30	100	18.22	23.79	21.34	17.02	21.60	19.48	18.39	14.80	18.69	7.28	19.39	17.43
31	0—50	14.52	15.11	14.70	14.96	14.39	14.79	13.27	13.10	13.19	12.41	12.62	12.60
32	50—100	19.89	20.40	20.30	21.10	21.17	20.86	14.85	14.62	14.74	15.53	14.71	15.00
33	0—100	17.20	17.76	17.50	18.02	17.58	17.79	14.06	13.86	13.96	13.94	13.67	13.79
no. of s. villages/blocks		353	353	706	(462)	(462)	(924)	(238)	(228)	(466)	(585)	(583)	(1168)
no. of s. households		931	938	1869	728	738	1466	224	223	447	237	252	489

NATIONAL SAMPLE SURVEY : Round 8 : July 1954–March 1955 and Round 13 : September 1957–May 1958

TABLE 8 : EXPENDITURE ON CEREALS AS PERCENTAGE OF CONSUMER EXPENDITURE : ALL-INDIA, RURAL AND URBAN

serial no.	fractile group (per cent)	expenditure on cereals as percentage of consumer expenditure											
		rural						urban					
		round 8			round 13			round 8			round 13		
		s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.	s.s.1	s.s.2	comb.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	1	28.22	55.56	43.80	44.35	46.37	47.60	58.00	59.20	48.23	35.76	68.36	60.45
2	2	51.28	54.04	53.45	61.49	53.65	56.58	46.17	59.13	59.72	70.12	51.36	58.50
3	3	54.52	55.06	48.85	59.23	61.01	56.22	49.82	40.04	44.12	53.54	38.36	51.25
4	4	31.30	57.81	48.56	66.17	65.28	64.88	50.42	56.31	55.13	60.91	56.10	51.82
5	5	50.71	52.33	53.62	55.95	65.46	63.05	52.18	43.09	51.83	48.61	54.85	53.49
6	0— 5	44.63	55.00	50.26	58.40	59.96	58.95	49.29	51.16	52.01	57.27	53.60	54.41
7	5—10	51.23	55.01	52.29	55.59	61.02	57.55	49.26	45.36	45.73	44.67	52.42	49.43
8	10—15	53.90	49.03	51.49	57.24	58.06	56.57	44.55	47.24	46.99	38.35	48.10	44.35
9	15—20	50.30	50.36	50.37	57.02	59.41	58.22	46.88	42.98	47.06	48.67	48.17	47.91
10	20—25	53.25	51.79	50.85	55.91	66.20	58.26	45.29	37.97	40.51	42.53	36.94	39.86
11	25—30	46.10	51.56	50.42	51.71	59.55	54.49	40.81	34.65	40.51	39.01	48.75	44.06
12	30—35	52.00	52.65	52.11	49.92	56.28	53.87	41.53	30.89	36.39	41.34	34.16	40.28
13	35—40	51.13	49.59	50.51	47.21	52.01	49.84	37.02	34.85	33.02	44.89	31.48	38.14
14	40—45	44.67	46.74	45.81	41.40	55.95	49.29	34.64	31.04	33.77	40.85	36.07	29.02
15	45—50	46.20	46.83	46.46	48.33	53.47	49.13	32.18	27.10	32.19	27.30	30.32	34.94
16	50—55	48.15	47.04	47.49	49.32	44.00	45.29	31.18	24.57	28.50	44.37	27.13	33.00
17	55—60	43.46	45.20	44.39	46.94	42.11	44.48	28.86	27.36	25.67	32.69	28.72	27.61
18	60—65	45.02	50.29	42.58	46.62	45.35	46.20	25.95	23.11	24.91	30.38	33.82	32.19
19	65—70	40.35	37.54	39.05	46.28	42.94	45.56	29.04	19.05	24.08	26.01	23.86	24.34
20	70—75	35.29	39.27	36.79	40.73	39.13	39.35	22.18	16.45	20.67	30.52	29.52	30.09
21	75—80	42.66	32.43	34.63	40.66	38.38	38.55	21.02	18.39	17.77	26.56	22.57	25.13
22	80—85	32.34	30.07	31.25	34.77	33.96	35.15	15.85	16.18	17.45	24.32	20.30	20.05
23	85—90	30.62	34.35	32.02	42.06	33.54	36.83	15.68	13.30	15.64	19.10	18.72	18.59
24	90—95	27.84	27.59	27.95	30.87	31.14	30.71	12.95	11.78	13.30	15.31	14.39	15.09
25	95—100	13.91	19.44	16.58	16.61	18.09	17.91	10.40	6.62	7.37	10.26	9.39	9.28
26	96	26.59	25.70	25.56	24.97	22.65	23.29	16.66	8.21	9.50	14.75	15.87	13.64
27	97	17.92	18.97	23.37	25.18	27.53	25.48	10.88	7.90	8.70	13.16	12.34	11.99
28	98	18.28	27.47	18.85	18.45	24.46	18.44	8.91	6.21	9.43	8.43	8.35	9.61
29	99	14.49	18.61	16.92	15.43	16.02	13.48	8.70	6.82	6.15	8.20	8.17	7.63
30	100	6.97	13.57	9.94	7.69	9.29	7.53	7.41	5.08	5.77	2.76	9.99	8.02
31	0—50	49.28	50.25	49.68	51.02	56.36	53.54	37.90	35.86	36.56	40.11	40.00	40.27
32	50—100	28.78	31.80	30.29	36.34	34.36	35.16	18.40	14.44	16.31	21.60	19.77	20.47
33	0—100	34.56	36.67	35.36	41.56	40.97	40.56	24.33	19.32	21.41	26.58	24.88	25.66
no. of s. villages/blocks		353	353	706	(462)	(462)	(924)	(238)	(228)	(466)	(585)	(583)	(1168)
no. of s. households		931	938	1869	728	738	1466	224	223	447	237	252	489

NOTE ON RISLEY'S ANTHROPOMETRIC DATA

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SUMMARY. From an examination of the printed records of Risley's anthropometric data it has been found that apart from clerical and printing errors, another type of error exists in a portion of the data. This type of error is due to the fact that observations were originally made in inches and pounds and were later converted into centimetres and grammes.

Sir H. H. Risley, I.C.S. who after the Population Census of 1881 was entrusted with the task of making an anthropological study of the tribes and castes of Northern India published in 1891 the measurements carried out under his instructions in two volumes with the title *The Tribes and Castes of Bengal, Anthropometric Data.* The measurements were made during the period 1886-88.

Mahalanobis (1931) carried out a critical examination of the printed data as they appear in the portion of Vol. I relating to Bengal and published a large number of corrections to individual values and Risley's averages, in a paper in *Sankhyā*. This is a masterly work embodying the result of a careful and painstaking scrutiny of the craniological measurements and indices. The present paper which may be regarded as a small extension of this scrutiny points out a source of inaccuracy in some of the records of stature and weight which were not considered by Mahalanobis.

Recently I had occasion to work with Risley's data in connection with an investigation of variations in Indian stature. During the course of this work I came up against the finding that part of Risley's data on stature though recorded in centimetres with one decimal place must have originally been made in inches and later on converted into centimetres by multiplying by the factor 2.54.

If one looks through the columns of figures representing measurements of stature the fact that these were not originally made in centimetres is not immediately obvious. In fact Vol. I giving measurements relating to Bengal, Chittagong Hills, Darjeeling Hills and Chotanagpur Hills does not show any peculiarity as the measurements in this volume must have been taken directly in centimetres. Even in Vol. II the data relating to Bihar which comes in the beginning are genuine centimetres. In the next series relating to 'North-Western Provinces and Oudh' it is obvious that the majority of measurements were originally made in inches though there are a small number that were either made in centimetres, or correct to decimals of an inch, or contain an element of clerical or printing error. In the measurements relating to Punjab at the end of Vol. II the inches appear clearly through the series of centimetres. By chance I happened to sort out the measurements for Punjab first instead of beginning with Vol. I.

The frequency distribution of Punjab statures is given in Table 1. The fact that all readings in Table 1 correspond either to multiples of inches or are midway between multiples of inches should be sufficient evidence to show that the measurements must have been originally made in inches. Risley does not mention this anywhere and it is doubtful whether he was aware of what actually happened. Risley states that Professor Topinard's methods of measuring were followed throughout. It is not easy to get hold of Professor Topinard's book in which he must have explained his methods. But it is very unlikely that Professor Topinard would have prescribed that the measurements may be first made in inches and then converted into centimetres. This must have been the responsibility of Alauddin, Civil Hospital Assistant, Lahore who took the measurements and to whom Risley has made cordial acknowledgements.

The figures as they are printed give the impression that measurements are correct to the nearest millimetre. Actually they are correct only to the nearest inch though about one tenth of the measurements are given to the nearest half inch. The converted values are therefore likely to be misleading. The multiplications have also not been correctly done in all cases. If the correct conversion factor is used we get the values given in col. 4 of Table 1 as against those in col. 1 which are actually printed by Risley. Out of a total of 452 values as many as 183 are in error by 0.1 cm due to inaccurate conversion. The error introduced in this way may perhaps be regarded as negligible even though for the Punjab data the true value is always larger than the printed value. The real danger is in producing a wrong impression of accuracy.

The data relating to North-Western Provinces and Oudh (the present-day Uttar Pradesh) must also have been wholly or mostly produced in the same way as the data for Punjab. Risley states that these measurements were made by Chandi Sing, clerk in the office of the Inspector of Schools, Oudh.

The frequency of different values is shown in Table 2. Of the 1817 values 1195 or nearly two thirds can be identified with whole inches. Another 422 values correspond to half inches leaving only 200 values which are not multiples of half inch. A further 141 values can be accounted for as multiples of one fourth inch adopting the rule that a comparatively large frequency about midway between two successive multiples of half inch corresponds to a quarter inch or three quarter inch. It can be seen that the conversions have been rather clumsily done so that a quarter inch equals anything from 0.5 cms to 0.8 cms. The remaining 59 values must be assumed to be the result of errors of recording or errors of calculation. There is also a remote possibility that some values may have been measured correct to inches and decimals of an inch.

In col. 4 of Table 2 we give the correct values in centimetres corresponding to the values in inches given in col. 3. We have also ventured to make guesses of the possible correct values in some of the cases where col. 3 is blank, mostly using neighbouring values in col. 1. Cols. 5 and 10 give the difference between the corrected values and the values as printed by Risley. It will be seen that as many as 721 of the printed values are in error by 0.1 cm, 62 are in error by 0.2 cms and for the remaining 32 it is not possible to say what the error is. The correct values number 1002 out of 1817.

The measurements relating to Bengal, Chittagong Hills, Darjeeling Hills, Chotanagpur Hills and Bihar seem to have been made directly in centimetres. The frequencies of different values in these series are given in Tables 3 to 7.

While going through Risley's records of stature some instances of misprints were noticed. These are listed in Table 8. It was easy to check on these figures as records of weight as well as the 'height-weight index' were available.

Records of weight as printed also appeared suspicious as each reading was expressed in six digits correct to the nearest tenths of a gramme. To test the possibility that these were also originally made in pounds and later converted into grammes roughly one fifth of the data (every fifth page) was sorted out to find the frequency of different values. The result is given in Table 9 from which it is clear that original weights must have been in pounds. Out of 949 values in Table 9 as many as 920 correspond to integral multiples of pounds. Of the remaining values 12 can be identified as half pounds leaving only 17 values unidentified in terms of pounds. In Table 9 we have ignored all obvious errors which affect only the last one or two digits. In most cases the conversions from pounds into gramme do not seem to have been done as correctly as the number of digits retained require.

TABLE 1. FREQUENCY DISTRIBUTION OF MEASUREMENTS OF STATURE FROM PUNJAB: RISLEY, 1891

cms	frequency	inches	cms corrected	diff. 4–1
(1)	(2)	(3)	(4)	(5)
152.4	2	60	152.4	.0
154.9	3	61	154.9	.0
156.2	1	61½	156.2	.0
157.4	12	62	157.5	.1
158.7	6	62½	158.7	.0
160.0	22	63	160.0	.0
161.2	3	63½	161.3	.1
162.5	43	64	162.6	.1
163.8	7	64½	163.8	.0
165.1	58	65	165.1	.0
166.3	8	65½	166.4	.1
167.6	83	66	167.6	.0
168.9	7	66½	168.9	.0
170.1	74	67	170.2	.1
171.4	8	67½	171.4	.0
172.7	45	68	172.7	.0
173.9	5	68½	174.0	.1
175.2	34	69	175.3	.1
176.5	1	69½	176.5	.0
177.8	10	70	177.8	.0
180.3	11	71	180.3	.0
182.8	4	72	182.9	.1
185.4	3	73	185.4	.0
186.6	1	73½	186.7	.1
190.5	1	75	190.5	.0
total	452			

TABLE 2. FREQUENCY DISTRIBUTION OF MEASUREMENTS OF STATURE FROM NORTH-WESTERN PROVINCES AND OUDH : RISLEY, 1891

cms	frequency	inches	cms corrected	diff. 4−1	cms	frequency	inches	cms corrected	diff. 9−6
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
142.2	1	56	142.2	.0	165.1	255	65	165.1	.0
144.7	1	57	144.8	.1	165.6	2	—	165.7	.1
147.3	5	58	147.3	.0	165.8	8	65¼	165.7	−.1
148.5	3	58½	148.6	.1	166.3	73	65½	166.4	.1
149.8	13	59	149.9	.1	166.8	8	65¾	167.0	.2
151.1	3	59½	151.1	.0	167.1	2	—	—	—
152.4	35	60	152.4	.0	167.4	5	—	—	—
152.9	1	—	153.0	.1	167.6	189	66	167.6	.0
153.1	1	60¼	153.0	−.1	168.1	2	—	—	—
153.6	16	60½	153.7	.1	168.4	6	66¼	168.3	−.1
154.1	4	60¾	154.3	.2	168.6	2	—	—	—
154.9	59	61	154.9	.0	168.9	55	66½	168.9	.0
155.7	11	61¼	155.6	−.1	169.1	2	—	—	—
156.2	23	61½	156.2	.0	169.4	10	66¾	169.5	.1
156.7	9	61¾	156.8	.1	170.0	3	—	—	—
157.4	116	62	157.5	.1	170.1	101	67	170.2	.1
157.8	1	—	—	—	170.7	1	—	170.8	.1
158.2	9	62¼	158.1	−.1	170.9	6	67¼	170.8	−.1
158.7	48	62½	158.7	.0	171.4	27	67½	171.4	.0
159.0	2	—	—	—	171.9	3	67¾	172.1	+.2
159.2	7	62¾	159.4	.2	172.6	1	—	172.7	.1
160.0	139	63	160.0	.0	172.7	50	68	172.7	.0
160.4	1	—	—	—	173.4	1	68¼	173.4	.0
160.5	1	—	—	—	173.9	18	68½	174.0	.1
160.7	6	63¼	160.7	.0	174.4	3	68¾	174.6	.2
161.2	60	63½	161.3	.1	175.2	30	69	175.3	.1
161.5	1	—	—	—	176.5	6	69½	176.5	.0
161.7	18	63¾	161.9	.2	177.0	1	69¾	177.2	.2
162.1	1	—	—	—	177.8	7	70	177.8	.0
162.5	189	64	162.6	.1	177.9	1	—	177.8	−.1
162.7	2	—	—	—	179.0	2	70½	179.0	.0
162.8	1	—	—	—	179.2	1	—	—	—
163.0	4	—	163.2	.2	179.3	1	—	—	—
163.3	15	64¼	163.2	−.1	179.5	1	70¾	179.7	.2
163.5	1	—	—	—	180.3	3	71	180.3	.0
163.8	87	64½	163.8	.0	181.6	1	71½	181.6	.0
164.2	1	—	—	—	182.1	1	71¾	182.2	.1
164.3	13	64¾	164.5	.2	182.8	1	72	182.9	.1
164.5	1	—	—	—	187.9	1	74	188.0	.1
165.0	17	—	165.1	.1	total	1817			

TABLE 3. FREQUENCY DISTRIBUTION OF MEASUREMENTS OF STATURE FROM BENGAL: RISLEY, 1891

cms	.0	.2	.3	.4	.6	.8	total
143	—	—	—	1	—	—	1
144	1	—	—	—	—	—	1
145	1	—	—	—	—	—	1
146	—	—	—	—	1	—	1
147	2	2	—	1	—	—	5
148	—	—	—	1	—	—	1
149	5	—	—	1	—	1	7
150	8	—	—	1	2	3	14
151	8	1	—	2	3	—	14
152	6	—	—	3	4	—	13
153	13	4	—	5	6	3	31
154	14	3	—	8	9	7	41
155	20	5	—	10	6	4	45
156	11	8	—	10	11	6	46
157	15	5	—	14	12	3	49
158	22	10	—	11	16	10	69
159	22	16	—	17	17	17	89
160	39	10	1	12	11	6	77
161	36	13	—	15	12	10	86
162	23	15	—	16	15	9	78
163	30	12	—	15	11	1	69
164	31	13	—	13	14	4	75
165	20	16	—	14	10	10	70
166	31	8	—	11	7	7	64
167	13	8	—	12	7	6	46
168	19	8	—	6	9	2	44
169	18	6	—	8	4	3	39
170	14	3	—	3	3	2	25
171	10	6	—	2	3	—	21
172	9	3	—	7	4	1	24
173	7	2	—	3	1	2	15
174	9	2	—	1	4	1	17
175	5	—	—	2	2	—	9
176	3	—	—	—	—	—	3
177	1	1	—	—	—	—	2
178	1	—	—	—	—	—	1
179	1	1	—	—	—	—	2
181	1	—	—	—	—	—	1
185	1	—	—	—	—	—	1
total	470	181	1	225	204	118	1199

TABLE 4. FREQUENCY DISTRIBUTION OF MEASUREMENTS OF STATURE FROM CHITTAGONG HILLS: RISLEY, 1891

cms	.0	.2	.4	.6	.8	total
148	—	—	—	1	—	1
149	2	—	—	—	2	4
150	1	—	1	1	—	3
152	—	2	1	2	2	7
153	2	2	2	3	2	11
154	4	3	3	8	—	18
155	6	—	3	8	—	17
156	8	2	6	3	—	19
157	7	6	5	5	3	26
158	4	2	1	6	—	13
159	8	2	2	3	3	18
160	11	2	3	1	2	19
161	10	2	2	5	1	20
162	9	4	4	4	—	21
163	8	2	—	6	—	16
164	3	2	3	2	—	10
165	10	1	—	3	—	14
166	6	1	—	1	1	9
167	5	—	2	1	2	10
168	2	1	2	1	2	8
169	3	3	1	1	—	8
170	3	1	—	—	—	4
171	1	1	—	—	—	2
174	—	1	—	—	—	1
175	1	—	—	—	—	1
total	114	40	41	65	20	280

TABLE 5. FREQUENCY DISTRIBUTION OF MEASUREMENTS OF STATURE FROM DARJEELING HILLS : RISLEY, 1891

cms	.0	.1	.2	.4	.5	.6	.7	.8	.9	total
141	–	–	–	–	–	1	–	–	–	1
145	1	–	–	–	–	–	–	–	–	1
147	2	–	–	–	–	2	–	–	–	4
149	3	–	–	1	–	–	–	–	–	4
150	4	–	–	–	–	1	–	1	–	6
151	4	1	1	1	–	3	–	–	–	10
152	5	–	1	5	–	2	–	1	–	14
152	2	–	–	5	–	4	–	–	–	11
154	6	–	3	4	–	1	–	3	3	20
155	12	–	1	1	–	1	–	1	–	16
156	10	–	2	1	-	6	–	1	–	20
157	10	–	2	5	–	6	–	2	–	25
158	7	–	5	2	–	2	2	4	–	22
159	6	–	2	6	–	7	–	–	–	21
160	9	–	7	6	–	7	–	2	–	31
161	10	–	3	6	1	3	–	4	–	27
162	8	–	–	3	3	3	–	4	–	21
163	7	–	5	2	–	1	–	4	–	19
164	3	–	6	1	–	5	–	2	–	17
165	5	3	3	7	–	3	–	1	–	22
166	8	–	1	5	–	3	–	1	–	18
167	7	–	1	2	–	–	–	1	–	11
168	5	–	1	2	–	3	–	–	–	11
169	1	–	–	2	–	–	–	1	–	4
170	4	–	–	1	–	3	–	–	–	8
171	3	–	–	1	–	–	–	–	–	4
172	1	–	–	2	–	1	–	1	–	5
173	1	–	–	2	–	1	–	–	–	4
174	1	–	1	–	–	1	–	–	–	3
175	1	–	2	–	–	–	–	–	–	3
176	2	–	–	–	–	–	–	–	–	2
total	148	4	47	73	4	70	2	34	3	385

TABLE 6. FREQUENCY DISTRIBUTION OF MEASUREMENTS OF STATURE FROM CHOTANAGPUR HILLS : RISLEY, 1891

cms	.0	.1	.2	.3	.4	.5	.6	.8	total
144	–	–	–	–	–	–	1	–	1
146	3	–	–	–	–	–	1	–	4
147	4	–	–	–	–	–	–	–	4
148	4	–	1	–	2	–	2	1	10
149	5	–	1	–	1	–	1	1	8
150	13	–	–	–	1	–	2	1	17
151	7	–	2	–	5	–	1	1	16
152	7	–	3	–	6	–	5	3	24
153	11	–	3	–	7	–	4	2	27
154	19	–	4	–	8	–	8	8	47
155	25	–	8	–	10	–	13	2	58
156	19	–	9	–	7	–	7	4	46
157	17	–	7	–	8	–	8	11	51
158	21	–	20	1	8	–	14	8	72
159	27	–	12	–	15	–	12	4	70
160	29	1	6	–	15	–	14	3	68
161	29	–	7	–	9	–	13	9	67
162	28	–	12	–	14	–	5	6	65
163	19	–	13	1	12	–	12	6	63
164	19	–	11	–	14	–	5	5	54
165	13	–	8	–	3	–	7	4	35
166	15	–	7	–	5	–	6	1	34
167	11	–	7	–	5	–	6	1	30
168	14	–	3	–	2	1	4	3	27
169	5	–	1	–	8	–	3	4	21
170	9	–	–	–	–	–	–	1	10
171	2	–	2	–	1	–	–	1	6
172	2	–	–	–	–	–	1	1	4
173	1	–	–	–	2	–	–	–	3
174	–	–	–	–	1	–	–	–	1
177	1	–	–	–	–	–	–	–	1
178	–	–	2	–	–	–	–	–	2
total	379	1	149	2	169	1	155	90	946

TABLE 7. FREQUENCY DISTRIBUTION OF MEASUREMENTS OF STATURE FROM BIHAR: RISLEY, 1891

cms	.0	.1	.2	.4	.6	.8	total
148	1	–	–	–	–	–	1
149	1	–	1	1	1	1	5
150	3	–	2	2	–	1	8
151	4	–	–	–	3	–	7
152	4	–	1	3	–	2	10
153	4	–	2	1	4	–	11
154	7	–	–	2	2	4	15
155	8	–	5	7	4	3	27
156	7	–	5	6	7	2	27
157	10	–	5	2	9	6	32
158	9	–	8	6	6	2	31
159	19	–	3	4	1	8	35
160	23	1	3	8	3	5	43
161	13	–	7	9	3	2	34
162	21	–	9	5	4	1	40
163	23	–	9	9	7	2	50
164	19	–	5	12	9	4	49
165	21	–	7	12	5	7	52
166	12	–	6	12	6	3	39
167	17	–	4	3	4	2	30
168	14	–	6	5	5	–	30
169	13	–	2	8	6	3	32
170	9	–	3	6	1	1	20
171	8	–	2	3	5	2	20
172	7	–	3	4	1	2	17
173	4	–	–	2	–	4	10
174	5	–	–	2	–	1	8
175	5	–	1	1	–	–	7
176	3	–	–	1	–	2	6
177	3	–	1	–	–	–	4
178	2	–	–	–	–	–	2
179	2	–	–	–	–	–	2
184	1	–	–	–	–	–	1
total	302	1	100	136	96	70	705

TABLE 8. SOME MISPRINTS IN THE VALUES OF STATURE: RISLEY, 1891

vol.	page	s.n.	stature printed	stature correct
I	46	13	167	167.0
I	67	24	104.8	165.2
II	641	66	102.5	162.5
II	753	73	134.9	154.9
II	754	94	196.6	167.6
II	834	42	112.5	162.5

TABLE 9. FREQUENCY DISTRIBUTION OF A SAMPLE OF WEIGHTS FROM RISLEY, 1891

grammes as given by Risley (1)	equivalent lbs (2)	frequency (3)	grammes as given by Risley (4)	equivalent lbs (5)	frequency (6)
33565.8	74	1	51936.2	—	1
38101.8	84	1	52163.0	115	28
38555.3	85	2	52616.6	116	36
39008.9	86	5	52843.4	—	1
39462.5	87	2	53048.7	—	1
39916.0	88	8	53070.2	117	18
40369.6	89	4	53296.4	—	1
40596.4	—	1	53523.8	118	27
40823.2	90	4	53776.6	—	1
41276.8	91	6	53977.4	119	14
41286.8	—	1	54431.0	120	39
41302.8	—	1	54884.6	121	10
41630.4	—	1	55338.2	122	17
41730.8	92	11	55791.8	123	9
42184.0	93	8	56123.0	—	1
42410.5	—	1	56245.4	124	15
42637.6	94	18	56472.1	—	1
43091.2	95	11	56699.0	125	12
43544.8	96	18	57152.5	126	10
43998.4	97	21	57255.8	—	1
44452.0	98	22	57606.1	127	10
44678.7	—	1	58061.7	128	9
44905.6	99	10	58513.3	129	5
45132.1	—	1	58836.9	—	1
45359.2	100	28	58966.9	130	13
45812.7	101	11	59420.5	131	8
46039.5	—	1	59874.1	132	5
46266.3	102	23	60327.7	133	3
46789.9	103	15	60781.3	134	10
47020.7	—	1	60872.0	—	1
47173.5	104	46	60960.9	—	1
47400.3	—	1	61234.9	135	1
47627.1	105	17	61688.5	136	2
47637.1	—	1	62142.1	137	1
48080.7	106	48	62553.7	—	1
48534.3	107	22	62595.6	138	3
48761.1	—	1	63049.2	139	2
48987.9	108	41	63502.8	140	6
49441.5	109	20	63956.4	141	1
49895.1	110	37	64410.0	142	2
50348.7	111	22	64863.6	143	1
50802.3	112	47	65317.2	144	1
50915.9	—	1	66224.4	146	1
50960.9	—	1	67131.6	148	1
51255.8	113	20	67585.2	149	1
51709.4	114	47	68038.8	150	3
51915.9	—	1	71730.3	—	1
				total	949

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GENERALIZED UNBIASED ESTIMATION IN SAMPLING FROM FINITE POPULATIONS

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SUMMARY. In this paper a technique of generating unbiased estimators for a certain class of parameters has been developed. The class of parameters considered consists of parameters which can be expressed as a sum of single-valued set functions defined over a class of sets of units belonging to a finite population. This technique is of importance, since so far unbiased estimators for any sample design have been suggested on *a priori* and intuitive considerations and not as a result of a systematic generating technique.

1. INTRODUCTION

In the last decade some attempts have been made to give generalized estimation procedures in sampling from finite populations, which would cover the estimators commonly used in practice as particular cases (Midzuno, 1950; Godambe, 1955; Murthy, Nanjamma and Sethi, 1959). Goodman (1953), Murthy (1957) and Basu (1958) have given techniques of improving upon certain types of estimators. In this paper it is proposed to develop a generalized estimation procedure on the lines considered by Murthy, Nanjamma and Sethi (1959) and to give a *technique of generating estimators* for any sample design. This technique is useful in the sense that it puts many estimators at our disposal. So far the estimators in case of different sample designs have been suggested by various authors on *a priori* and intuitive considerations and not as a result of a systematic generating technique. Of course, the problem of choice among different estimators remains and in most cases extensive empirical studies would be necessary to arrive at the best or near optimum estimators. This is because there does not exist a uniformly unbiased minimum variance estimator in the non-parametric sense in sampling from finite populations, as has been shown by Godambe (1955).

It is interesting to note that a particular general estimator given by the generating technique happens to include, as particular cases, most of the estimators commonly used in practice and this estimator may be taken as a *reasonable* estimator whenever there is doubt as to which estimator is to be used. To illustrate the application of this technique, the cases of sampling with varying probabilities without replacement is discussed in detail.

2. SAMPLE DESIGN AND SAMPLING SCHEME

A *sample design* may be considered as the specification of all possible samples with their probabilities of selection or of the probabilities of inclusion of the units or of combinations of units in the sample. A *sampling scheme* may be taken as the procedure of selection of the sample in stages by units or combinations of units.

A sample design is completely specified by a list of all possible samples including all possible permutations and repetitions of the units in the sample with their respective probabilities of selection. In such a case it can be seen that there is a unique sampling scheme which gives rise to the sample design, as has been formally shown by Hanumantha Rao (1960). Examples of partial specification of sample design are

(i) specification of all possible samples without considering the permutations and repetitions of the units in them with their probabilities; and

(ii) specification of the probabilities of inclusion of the units in the sample.

In case of a partially specified design, there is no unique sampling scheme giving rise to the sample design. In such cases the problem is to find that selection procedure which is most economical from the view points of cost and variance of a given estimator.

For instance, in case of a partially specified sample design where the probabilities of inclusion of the units in the sample (π_i's) are specified, a simple sampling scheme which is likely to be more efficient than the others is to select the sample with probability proportional to the probability of inclusion systematically after some suitable arrangement of the units (Grundy, 1954; Murthy, 1960). The procedure consists in first obtaining the cumulated totals of the probabilities of inclusion, and then selecting the units systematically with a random start from 0 to 1 and with 1 as the sampling interval using the cumulated totals of the π_i's.

3. Parametric function

Let X denote a finite population of N units (U_i, $i = 1, 2, \ldots, N$) and let the vector $\boldsymbol{X}_i$ giving the values of a number of characteristics, be associated with the i-th unit ($i = 1, 2, \ldots, N$). Let A be the class of all sets 'a' whose elements belong to X. In such a set the same unit may or may not occur more than once. The class of all point sets and the class of all pairs of units belonging to X are examples of the class A.

We shall confine ourselves to only such parametric functions (F, say) which can be expressed as a sum of single-valued set functions defined over the class A. That is, if F is such a function, then

$$F = \sum_{a \,\varepsilon\, A} f(a), \qquad \ldots \quad (3.1)$$

where $f(a)$ is a single-valued set function defined over the class A and $\sum\limits_{a \,\varepsilon\, A}$ stands for the summation over all sets 'a' belonging to the class A. For instance, the population total Y for a characteristic y can be expressed as F in (3.1) with 'a' as a point set (U_i) and $f(a)$ as Y_i. The population variance σ^2 can be expressed as F with 'a' as a set of two points $\{U_i, U_j\}$* and

$$f(a) = \frac{1}{N^2}\ (Y_i - Y_j)^2.$$

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* Bracess { } are used to denote unordered sets, that is, $\{U_i, U_j\}$ and $\{U_j, U_i\}$ are the same.

Similarly the covariance between two characteristics x and y also can be expressed as F in (3.1) with 'a' as a pair of units $\{U_i, U_j\}$ and

$$f(a) = \frac{1}{N^2}(Y_i - Y_j)(X_i - X_j).$$

It may be noted that there may be many ways of expressing a parameter in the form (3.1). For instance, the population total Y may as well be expressed as F with 'a' as a set of n distinct units and

$$f(a) = \frac{n\bar{y}}{\binom{N-1}{n-1}}$$

where $\bar{y}$ is the mean value of the units in the set 'a'. In such cases it is desirable to define the set 'a' over as small number of units of the population as possible and in what follows this is assumed to be so unless otherwise stated.

4. SAMPLE SPACE AND ESTIMABILITY

Let w_{or} be a set of elements of X taking into account the permutations and the repetitions of the units. The subscript 'o' and 'r' are used to denote the order and the repetitions of the units respectively. Let W_{or} be the class of all sets w_{or}. W_{or} may be considered the sample space. This together with a specified probability measure $P(w_{or})$ defined over it gives rise to a completely specified sample design. Before giving the generalized estimator for F, the procedures of improving upon certain types of estimators given by Murthy (1957) and Basu (1958) are considered in this context.

If $\hat{Y}_r$ is an unbiased estimator which takes into account the repetitions of the units in the sample, then a more efficient estimator which ignores the repetitions of the units and is based only on the distinct units in the sample w_{or} is given by

$$\hat{Y} = \frac{\sum\limits_{w_r \to w} \hat{Y}_r P(w_r)}{P(w)}, \qquad \dots \quad (4.1)$$

where w_r denotes a sample where the repetitions of the units are taken into account but not the arrangement of the units in the sample, $P(w_r)$ and $P(w)$ are the probabilities of getting the samples w_r and w respectively, where w is the sample ignoring the repetitions and arrangement of the units and $\sum\limits_{w_r \to w}$ denotes summation over all samples w_r corresponding to the sample w.

Similarly, if $\hat{Y}_o$ is an unbiased estimator of Y based on the ordered sample w_o, then a more efficient estimator which is based on the unordered sample w corresponding to w_o is given by

$$\hat{Y} = \frac{\sum\limits_{w_0 \to w} \hat{Y}_o P(w_o)}{P(w)} \qquad \dots \quad (4.2)$$

where $\sum\limits_{w_0 \to w}$ denotes summation over all possible ordered samples w_o corresponding to the unordered sample w.

For the sake of convenience, let us consider the case where the sample size is fixed. Let 's' be a set of units of X with or without repetitions and with or without arrangement of units, as the case may be. The class of all such sets is the sample space 'S' and let the probability of getting the sample 's' be $P(s) > 0$. It may be noted that 's' is being used here to denote w_{or}, w_o, w_r or w as the case may be. Without loss of generality, it may be assumed that each sample 's' consists of at least one set 'a'. If this were not so, we can redefine the sample space and the probability measure such that this is so.

Theorem 1 : *The parametric function F given in (3.1) can be estimated unbiasedly from the sample if and only if each set 'a' is contained in at least one sample 's'.*

Proof : That the condition is sufficient can easily be seen by considering the estimator

$$\hat{F} = \frac{\sum\limits_{a \subset s} f(a)\phi(s, a)}{P(s)}, \qquad \ldots \quad (4.3)$$

where $\phi(s, a)$ is some function of 's' and 'a'. The necessary and sufficient condition for this estimator to be unbiased for F is that

$$\sum_{s \supset a} \phi(s, a) = 1 \qquad \ldots \quad (4.4)$$

for

$$E(\hat{F}) = \sum_{s \in S} \sum_{a \subset s} f(a)\,\phi(s, a) = \sum_{a \in A} f(a) \sum_{s \supset a} \phi(s, a).$$

There are a number of functions satisfying (4.4), as can easily be verified.

The necessity of the condition can be proved as follows. Suppose some set 'a' is not included in any sample. Then the coefficient of the corresponding $f(a)$ in $E(\hat{F})$ given above will be 0 and not 1. Hence the necessity for the condition.

Theorem 2. *An unbiased estimator of the variance of the estimator $\hat{F}$ given in (4.3) can be obtained if and only if every set (aUa') is contained in at least one sample 's'.*

Proof : For estimation of the variance of F unbiasedly, it is sufficient to estimate F^2 unbiasedly, for

$$E(\hat{F}^2) = V(\hat{F}) + F^2$$

that is,

$$\text{est } V(\hat{F}) = \hat{F}^2 - \text{est } F^2.$$

F^2 can be expressed as

$$F^2 = \sum_{a \in A} \sum_{a' \in A} f(a) f(a').$$

From this it follows that an unbiased estimator of F^2 is possible if and only if every set (aUa') is included in at least one sample 's' (cf. Theorem 1).

An unbiased estimator of $V(\hat{F})$ is given by

$$\hat{V}(\hat{F}) = \frac{\hat{F}^2 - \left[\sum\limits_{a \subset A} \sum\limits_{a' \subset s} f(a)\, f(a')\, \psi(s, aUa')\right]}{P(s)}, \qquad \ldots \quad (4.5)$$

where

$$\sum_{s \supset aUa'} \psi\, (s, aUa') = 1. \qquad \ldots \quad (4.6)$$

If some supplementary information (say $g(a)$) related to $f(a)$ is available for all the sets in 'A' and is made use of at the selection stage, then it is desirable that whenever $g(a)$ is substituted for $f(a)$ in the estimator (4.3), we get the population parameter

$$G(a) = \sum_{a \varepsilon A} g(a).$$

In other words it is desirable to find $\phi(s, a)$ in the estimator (4.3) such that

$$\sum_{s \supset a} \phi(s, a) = 1$$

and

$$\frac{\sum\limits_{a \subset s} g(a)\, \phi(s, a)}{P(s)} = G. \qquad \ldots \quad (4.7)$$

for each sample 's'.

5. Generalized unbiased estimators

It is proposed to consider the estimator given in (4.3), namely,

$$\hat{F} = \frac{\sum\limits_{a \subset s} f(a)\, \phi\, (s, a)}{P(s)} \qquad \ldots \quad (5.1)$$

and to give a technique for generating unbiased estimators for any sample design. As has been shown earlier, $\hat{F}$ in (5.1) is unbiased for F if and only if

$$\sum_{s \supset a} \phi\, (s, a) = 1. \qquad \ldots \quad (5.2)$$

One solution for (5.2) is given by

$$\phi(s, a) = \frac{1}{N(s \supset a)}, \qquad \ldots \quad (5.3)$$

where $N(s \supset a)$ stands for the number of samples containing the set 'a'. In that case the estimator is given by

$$\hat{F}_1 = \frac{\sum\limits_{a \subset s} f(a)}{N(s \supset a)\, P(s)} \qquad \ldots \quad (5.4)$$

where $\sum\limits_{a \subset s}$ stands for summation over all sets 'a' included in the sample 's'.

Theorem 3 : *An unbiased estimator of F given in* (3.1) *is given by*

$$\hat{F} = \frac{\sum\limits_{a \subset s} f(a)\, P(s/E_a)}{P(s)}, \qquad \ldots \quad (5.5)$$

where E_a *is any event concerning the occurrence of the set 'a' in the sample satisfying the following conditions:*

(i) *the occurrence of* E_a *implies the selection of one* $s \supset a$, *and*

(ii) *the selection of 's' implies the occurrence of* E_a *for at least one* $a \subset s$,

and $P(s/E_a)$ *is the conditional probability of selecting the sample 's' given that the event* E_a *has occurred.*

Proof: The theorem will be proved if we can show that the condition (5.2) is satisfied when

$$\phi(s, a) = P(s/E_a).$$

In this case the condition is satisfied, for

$$P(s/E_a) = \frac{P(s, E_a)}{\sum\limits_{s\supset} P(s, E_a)},$$

where $P(s, E_a)$ is the probability of getting the sample 's' where the event E_a has occurred and hence

$$\sum_{s\supset} P(s/E_a) = 1.$$

Since $P(s/E_a)$ satisfies (5.2) for all specifications of the event E_a satisfying the conditions mentioned in Theorem 3, we can get many estimators by defining the event E_a in different ways. The event E_a may be termed the '*generating event*', since it generates estimators. For instance, the following specifications of the event may be considered:

(i) the set 'a' is included in the sample 's'—$E_{a\subset s}$,

(ii) the set 'a' occurs first in the ordered sample—E_{a1},

(iii) the set 'a' occurs in the second position in the ordered sample—E_{a2}

and so on. The estimator corresponding to the events $E_{a\subset s}$, E_{a1} and E_{a2} are given by

$$\hat{F}_2 = \frac{\sum\limits_{a\subset s} f(a)}{\pi(a)}, \qquad \dots \quad (5.6)$$

where $\pi(a)$ is the probability of including the set 'a' in the sample, since

$$P(s/E_{a\subset s}) = \frac{P(s)}{P(a \subset s)},$$

$$\hat{F}_3 = \frac{\sum\limits_{a\subset s} f(a)\, P(s/E_{a1})}{P(s)}, \qquad \dots \quad (5.7)$$

$$\hat{F}_4 = \frac{\sum\limits_{a\subset s} f(a)\; P(a/E_{a2})}{P(s)}. \qquad \dots \quad (5.8)$$

The estimator $\hat{F}_2$ satisfies the desirable condition mentioned in (4.7) if $\pi(a)$ is made proportional to the supplementary information $g(a)$ related to $f(a)$. For substituting $g(a)$ for $f(a)$ in (5.6) we get

$$\sum_{a \subset s} \frac{g(a)}{\pi(a)} = G$$

since $\sum_{a \varepsilon A} \pi(a)$ is the number of sets 'a' occurring in the sample 's'.

Similarly, the estimator $\hat{F}_3$ satisfies this condition if one set 'a' is selected with probability proportional to $g(a)$ in the first draw. For in that case we get

$$\sum_{a \subset} \frac{g(a)\, P(s/E_{a1})}{P(s)} = G$$

by substituting $g(a)$ for $f(a)$ in (5.7).

It may be noted that for the estimator to be useful in practice the generating event E_a should be so specified that it would be possible to calculate the conditional probability $P(s/E_a)$ from the information available about the population, the sample and the sampling scheme. For instance, if the event is defined as the occurrence of the set 'a' such that $f(a) < f(a')$ for all $a' \subset s$, it is not possible to calculate the conditional probability $P(s/E_a)$ since the values of $f(a)$ are available only for the sets 'a' included in the sample 's'.

The technique of generating estimators given above shows that given any sampling scheme, one can derive a number of unbiased estimators by defining the generating event E_a in different ways and choose one of them taking into consideration the cost and the efficiency. In other words, this technique gives rise to a variety of estimators to choose from. It can be easily verified that the estimator obtained by considering the event E_a as the occurrence of the set 'a' first in the ordered sample includes, as particular cases, most of the estimators commonly used in practice. Hence this estimator may be considered as a *reasonable estimator* and this may be used whenever there is doubt as to which estimator to use in particular situations. It may be noted that though the specification of the generating event takes into account the order of selection, the resulting estimator need not be an ordered estimator.

If the distinct units in the sample and the probabilities of selecting all possible unordered samples are given, then it will be possible to generate a number of possibly different unbiased estimators by

(i) specifying different sampling schemes giving rise to the partially specified sample design, and

(ii) defining the generating event in different ways.

To fix the ideas, let us consider the sample design specifying the unordered samples and their respective probabilities,

$$\{U_i, U_j\} \text{ and } \pi_{ij},$$

where $$\pi_{ij} = p_i p_j \left(\frac{1}{1-p_i} + \frac{1}{1-p_j} \right),$$

p_i's being less than 1 and $\sum_{i=1}^{N} p_i = 1$. Since the sampling scheme is unique for a completely specified sample design, we get different sampling schemes by specifying different ways of distributing the probability of the unordered sample $\{U_i, U_j\}$ over the ordered samples (U_i, U_j) and (U_j, U_i). For instance, let

$$P_1(U_i, U_j) = \frac{p_i p_j}{(1-p_i)} \text{ and } P_1(U_j, U_i) = \frac{p_i p_j}{(1-p_i)} \qquad \ldots \quad (5.9)$$

$$P_2(U_i, U_j) = \frac{\pi_{ij}}{2} \qquad \text{and } P_2(U_j, U_i) = \frac{\pi_{ij}}{2} \qquad \ldots \quad (5.10)$$

In both the cases $P(U_i, U_j)+P(U_j, U_i) = \pi_{ij}$. Let the generating event be the occurrence of the unit first in the ordered sample. For (5.9), $P(s/U_i1) = p_j/(1-p_i)$ and the estimator is

$$Y' = \frac{1}{2-p_i-p_j}\left[\frac{y_i}{p_i}(1-p_j)+\frac{y_j}{p_j}(1-p_i)\right], \qquad \ldots \quad (5.11)$$

whereas for the same generating event in case of (5.10), we get

$$Y'' = \frac{y_i}{\pi_i} + \frac{y_j}{\pi_j}, \quad \left(\pi_i = \sum_{j\neq i} \pi_{ij}\right). \qquad \ldots \quad (5.12)$$

Similarly other estimators can be obtained for different specifications of the generating event.

Another method of obtaining unbiased estimators using the above technique is to express the parametric function in the form of (3.1) in a number of ways by adopting different definitions for the class 'A' of the sets 'a'. For instance, the population total Y can be expressed as

$$Y = \frac{\Sigma\,(m\,\bar{y}_m)}{\binom{N-1}{m-1}}, \quad (m = 1, 2, \ldots, N), \qquad \ldots \quad (5.13)$$

where $\bar{y}_m$ is the mean based on a combination of m distinct units from the N units and Σ stands for the summation over all combinations of m units from the N units.

Thus we see that if a sample of size n is taken, then n possibly different estimators can be obtained by taking different values of $m(= 1, 2, \ldots, n)$ in (5.13). The estimators will be of the form

$$\hat{Y}_m = \frac{\Sigma_m(m\bar{y}_m)\phi(s, a)}{\binom{N-1}{m-1} P(s)}, \quad (m = 1, 2, \ldots, n), \qquad \ldots \quad (5.14)$$

where Σ_m stands for the summation over all combinations of m distinct units from n units in the sample and the set 'a' stands for a combination of m units from n units.

To summarize, it may be noted that a number of possibly different unbiased estimators can be obtained from (5.5) by different specifications of

(i) sampling scheme,

(ii) generating event, and

(iii) the set 'a'.

6. VARIANCE ESTIMATOR

In Section 4 it has been shown that an unbiased estimator of the variance of $\hat{F}$ is given by

$$\hat{V}(\hat{F}) = \hat{F}^2 - \frac{\left[\sum\limits_{\subset s} \sum\limits_{a' \subset s} f(a) f(a')\, \psi(s, aUa') \right]}{P(s)} \quad \ldots \quad (6.1)$$

where

$$\sum_{s \subset aUa'} \psi(s, aUa') = 1. \quad \ldots \quad (6.2)$$

Now we give a technique of generating unbiased variance estimators by giving a procedure for obtaining a number of solutions for (6.2). To start with, we may take

$$\psi(s, aUa') = 1/N(s \supset aUa'), \quad \ldots \quad (6.3)$$

where $N(s \supset aUa')$ stands for the number of samples containing the set $a\ Ua'$ and this gives rise to the following unbiased estimator of the variance of $\hat{F}$,

$$\hat{V}_1(\hat{F}) = \hat{F}^2 - \left[\sum_{a \subset s} \sum_{a' \subset s} f(a) f(a')/N(s \supset aUa')\, P(s) \right]. \quad \ldots \quad (6.4)$$

A number of possibly different unbiased estimators can be obtained by taking

$$\psi(s, aUa') = P(s/E_{aUa'}), \quad \ldots \quad (6.5)$$

where $P(\mathrm{a}/E_{aUa'})$ is the conditional probability of getting the sample 's' given that the generating event concerning the occurrence of the set (aUa') in the sample has occurred. It can be easily verified that this satisfies (6.2), for

$$P(s/E_{aUa'}) = \frac{P(s, aUa')}{\sum\limits_{s \supset aUa'} P(s, E_{aUa'})}.$$

Taking up the illustration considered in Section 5, we see that unbiased estimators of Y^2 in case of (5.9) and (5.10) are respectively given by

$$\frac{1}{2-p_i-p_j} \left[\frac{y_i^2}{p_i}(1-p_j) + \frac{y_j^2}{p_j}(1-p_i) \right] + 2\,\frac{y_i y_j}{\pi_{ij}} \quad \ldots \quad (6.6)$$

and

$$\frac{y_i^2}{\pi_i} + \frac{y_j^2}{\pi_j} + 2\,\frac{y_i y_j}{\pi_{ij}}. \quad \ldots \quad (6.7)$$

It may be noted that for each estimator there are a number of possibly different unbiased estimators generated by the above technique.

As mentioned earlier, it is proposed to consider in the next section the different estimators and their variance estimators generated by this technique, when it is applied to sampling with varying probabilities with and without replacement. For the sake of simplicity, only the question of estimating the population total Y of the characteristic y and the population variance σ^2 on the basis of a sample of fixed size is considered. Of course, this technique of generating unbiased estimators may be applied to get unbiased estimators of a number of other parametric functions, such as moments, which can be expressed in the form of F in (3.1).

7. VARYING PROBABILITY SAMPLING

With replacement scheme. Suppose n units are selected with probability proportional to a given measure of size with replacement where the probability of sampling the i-th unit at each draw is P_i $(i = 1, 2, \ldots, N)$. Let 's' be an unordered sample of d distinct units obtained by the above procedure taking into account the repetitions of the units in the sample and let p_i be the probability of slecting the i-th distinct unit in the sample 's'. In this case we get

$$P(s) = \frac{n!}{r_1!\, r_2! \ldots r_d!}\, p_1^{r_1} p_2^{r_2} \ldots p_d^{r_d},$$

where r is the number of repetitions of the i-th unit in the sample,

$$P(a/E_{im}) = \frac{(n-1)!}{r_1!\, r_2! \cdots (r_i-1)! \cdots r_d!}\, p_1^{r_1} p_2^{r_2} \ldots p_i^{r_i-1} \ldots p_d^{r_d}, \quad (m = 1, 2, \ldots n).$$

Hence we have

$$\hat{Y}_3 = \hat{Y}_4 = \hat{Y}_5 = \cdots = \hat{Y} = \frac{1}{n} \sum_{i=1}^{d} r_i \frac{y_i}{p_i}. \qquad \cdots \quad (7.1)$$

An unbiased estimator of the variance of this estimator is given by

$$\hat{V}(\hat{Y}) = \frac{1}{n(n-1)} \sum_{i=1}^{d} r_i \left(\frac{y_i}{p_i} - \hat{y} \right)^2 \qquad \cdots \quad (7.2)$$

since an unbiased estimator of Y^2 in this case is

$$\sum_{i=1}^{n} \sum_{j>i} \frac{(y_i y_j / p_i p_j)}{\binom{n}{2}}.$$

If we take the sample 's' as consisting of only the distinct units without taking into account the repetition or arrangement of the units in the sample, we get

$$\hat{Y}_2 = \frac{\sum_{i=1}^{d} y_i}{[1-(1-p_i)^n]} \qquad \cdots \quad (7.3)$$

since

$$\pi_i = 1-(1-p_i)^n,$$

and

$$\hat{Y}_3 = \frac{\sum_{i=1}^{d} y_i p(s/E_{i1})}{P(s)}. \qquad \cdots \quad (7.4)$$

The expression for the conditional probability $p(s/E_{i1})$ of getting the sample 's' given that the i-th distinct unit has been selected first is in general rather complicated. To illustrate the situation, let us consider the case where there are $(n-1)$ distinct units in the sample of n units selected with probability proportional to size with replacement.

Then

$$P(s) = \frac{n!}{1!\ 1! \dots 2!}\, p_1p_2 \cdots p_{n-1} \sum_{i=1}^{n-1} p_i$$

$$P(s/E_{i1}) = \frac{(n-1)!}{1!\ 1! \dots 1!\ 2!}\, p_1p_2 \cdots p_{n-1} \Big(\sum_{j\neq i}^{n-1} p_j \Big) / p_i$$

$$+ \frac{(n-1)!}{1!\ 1! \dots 1!}\, p_1\, p_2 \cdots p_{n-1}$$

$$= \frac{P(s)}{n} \Big[\frac{1}{p_i} + 1 \Big/ \Big(\sum_{i=1}^{n-1} p_i \Big) \Big].$$

Hence we get the estimator

$$\hat{Y}_3 = \frac{1}{n} \left[\sum_{i=1}^{n-1} \frac{y_i}{p_i} + \frac{\sum_{i=1}^{n-1} y_i}{\sum_{j=1}^{n-1} p_i} \right]. \qquad \dots \quad (7.5)$$

Incidentally this is the estimator obtained by improving the estimator (7.1) by using the technique suggested by Basu (1958).

Without replacement scheme. In sampling with varying probabilities without replacement, the generalized estimator gives rise to different estimators for different specifications of the generating event E concerning the occurrence of the i-th unit in the sample. For the sake of simplicity, let us consider the case where the sample size is 2.

Case (i) *: pps and pps of the remaining.* Let the selected unordered sample be $\{U_i, U_j\}$ and let the initial probabilities of selection for these units be p_i and p_j. In this case

$$P(s) = \pi_{ij} = \frac{p_ip_i(2-p_i-p_j)}{(1-p_i)(1-p_j)}\ , \quad N(s \supset i) = (N-1)$$

$$\pi(i) = \pi_i = \sum_{j\neq i} \pi_{ij}, \qquad\qquad p(s/i1) = \frac{p_j}{(1-p_i)}$$

$$P(s/i2) = \frac{p_ip_j}{(1-p_j)(\pi_i-p_i)}.$$

Unbiased estimators of Y corresponding to different solutions of (5.2) considered above are given by

$$\hat{Y}_1 = \frac{y_i+y_j}{(N-1)\pi_{ij}} \qquad \dots \quad (7.6)$$

$$\hat{Y}_2 = \frac{y_i}{\pi_i} + \frac{y_j}{\pi_j} \qquad \dots \quad (7.7)$$

$$\hat{Y}_3 = \frac{1}{(2-p_i-p_j)\,p}\left[\frac{y_i}{p_i}(1-p_j)+\frac{y_j}{p_j}(1-p_i)\right] \qquad \dots \quad (7.8)$$

$$\hat{Y}_4 = \frac{1}{(2-p_i-p_j)}\left[\frac{y_i}{(\pi_i-p_i)}(1-p_i)+\frac{y_j}{(\pi_j-p_j)}(1-p_j)\right]. \qquad \dots \quad (7.9)$$

It is of interest to note that (7.6) is a particular case of the estimator suggested by Midzuno (1950), (7.7) is the estimator suggested by Horvitz and Thompson (1952) and (7.8) was obtained by Murthy (1957) by unordering one of the ordered estimators considered by Des Raj (1956). The estimator (7.9) is a new estimator. Thus we see that all the estimators commonly known in varying probability sampling without replacement can be generated by the technique introduced here. There are two other estimators, namely,

$$\hat{Y}_5 = \frac{(\hat{Y}_1+\hat{Y}_3)}{2} \qquad \dots \quad (7.10)$$

$$\hat{Y}_6 = \frac{(\hat{Y}_3+\hat{Y}_4)}{2} \qquad \dots \quad (7.11)$$

which are obtained by unordering the ordered estimators

$$Y' = \frac{1}{2}\left[\frac{y_i}{p_i}+\frac{1}{(N-1)}\frac{(1-p_i)}{p_i}\frac{y_j}{p_j}\right], \qquad \dots \quad (7.12)$$

and

$$Y'' = \frac{1}{2}\left[\frac{y_i}{P_1(i)}+\frac{y_j}{P_2(j)}\right], \qquad \dots \quad (7.13)$$

where the ordered sample is (ij) and $P_1(i)$ and $P_2(j)$ are respectively the unconditional probabilities of getting the i-th unit in the first draw and the j-th unit in the second draw. The estimator in (7.12) was suggested by Das (1951) and that in (7.13) by Des Raj (1956). Here we see that the unordered estimators (7.10) and (7.11) corresponding to (7.12) and (7.13) are nothing but linear combinations of the estimators generated by the technique under consideration. One may as well consider other combinations of the estimators given in (7.6) to (7.9). That is, we may consider the estimators

$$\hat{Y}_7 = \frac{(\hat{Y}_1+\hat{Y}_2)}{2} \qquad \dots \quad (7.14)$$

$$\hat{Y}_8 = \frac{(\hat{Y}_1+\hat{Y}_4)}{2} \qquad \dots \quad (7.15)$$

$$\hat{Y}_9 = \frac{(\hat{Y}_2+\hat{Y}_3)}{2} \qquad \dots \quad (7.16)$$

$$Y_{10} = \frac{(\hat{Y}_2+\hat{Y}_4)}{2}. \qquad \dots \quad (7.17)$$

The unordered estimators corresponding to (7.12) and (7.13) in the general case, where the sample size is greater than 2, can be derived using the technique mentioned in (4.2).

It is of interest to note that of all the estimators given above only $\hat{Y}_3$ satisfies the desirable condition given in (3.7). For, in that case, if we substitute p_i for y_i in the estimator, we get 1 which is the total of the initial probabilities of all the units in the population.

Unbiased estimators of the variances of the estimators given above can be obtained, if unbiased estimators of Y^2 are given. In this case estimators of

$$\sum_{i=1}^{N} Y_i^2$$

can be obtained by substituting y_i^2 and y_j^2 for y_i and y_j in the above expressions. An unbiased estimator of

$$2 \sum_{i=1}^{N} \sum_{j>i} Y_i Y_i$$

is given by $$\frac{2y_iy_j}{\pi_{ij}}$$

Thus we see that for each estimator given above there are a number of variance estimators. For instance,

$$\left.\begin{aligned} \hat{V}_1(\hat{Y}_1) &= \hat{Y}_1^2 - \left[\frac{y_i^2+y_j^2}{(N-1)\pi_{ij}} + 2\,\frac{y_iy_j}{\pi_{ij}}\right] \\ \hat{V}_2(\hat{Y}_1) &= \hat{Y}_1^2 - \left[\frac{Yy_i^2}{\pi_i} + \frac{y_j}{\pi_j} + 2\,\frac{y_iy_j}{\pi_{ij}}\right], \text{ etc.} \end{aligned}\right\} \qquad \ldots \quad (7.18)$$

Similarly we get

$$\left.\begin{aligned} \hat{V}_1(\hat{Y}_2) &= \hat{Y}_2^2 - \left[\frac{y_i^2+y_j^2}{(N-1)\pi_{ij}} + 2\,\frac{y_iy_i}{\pi_{ij}}\right] \\ \hat{V}_2(\hat{Y}_2) &= \hat{Y}_2^2 - \left[\frac{y_i^2}{\pi_i} + \frac{y_j^2}{\pi_j} + 2\,\frac{y_iy_j}{\pi_{ij}}\right] \\ &= \frac{y_i^2}{\pi_i^2}(1-\pi_i) + \frac{y_j^2}{\pi_j^2}(1-\pi_j) + 2\,\frac{y_iy_j}{\pi_i\pi_i}\,\frac{(\pi_{ij}-\pi_i\pi)_j}{\pi_{ij}}\,, \end{aligned}\right\} \qquad \ldots \quad (7.19)$$

which is the variance estimator proposed by Horvitz and Thompson (1952) for their estimator (7.7),

$$\begin{aligned} \hat{V}_3(\hat{Y}_3) &= \hat{Y}_3^2 - \frac{1}{2-p_i-p_j}\left[\frac{y_i^2}{p_j}(1-p_j) + \frac{y_j^2}{p_j}(1-p_j) + 2\frac{y_iy_j}{p_ip_j}(1-p_i)(1-p_j)\right] \\ &= \frac{(1-p_i)(1-p_j)(1-p_i-p_j)}{(2-p_i-p_j)}\left(\frac{y_i}{p_i} - \frac{y_j}{p_i}\right), \end{aligned} \qquad \ldots \quad (7.20)$$

which is given by Murthy (1957) and so on.

Empirical studies. The small population given below is considered to compare the efficiencies of the above estimators Y_1 to Y_{10} empirically.

unit	u_1	u_2	u_3	u_4
p	0.1	0.2	0.3	0.4
y	0.5	1.2	2.1	3.2

This population was considered by Yates and Grundy (1953). The sampling scheme consists in selecting 2 units with the specified probabilities without replacement. The estimates for the 6 possible samples and the variance of the estimators are given in Table 1.

TABLE 1. ESTIMATES FOR ALL POSSIBLE SAMPLES OF 2 UNITS IN CASE OF DIFFERENT ESTIMATORS AND THEIR VARIANCES

sample	$\hat{Y}_1$	$\hat{Y}_2$	$\hat{Y}_3$	$\hat{Y}_4$	$\hat{Y}_5$	$\hat{Y}_6$	$\hat{Y}_7$	$\hat{Y}_8$	$\hat{Y}_9$	$\hat{Y}_{10}$
12	12.00	4.85	5.53	4.31	8.77	4.92	8.43	8.16	5.19	4.58
13	11.37	5.58	6.12	5.07	8.75	5.60	8.48	8.22	5.85	5.33
14	11.10	6.60	6.80	6.28	8.95	6.54	8.85	8.69	6.70	6.44
23	6.84	6.17	6.53	5.83	6.69	6.18	6.51	6.34	6.35	6.00
24	6.29	7.19	7.14	7.18	6.71	7.16	6.74	6.73	7.17	7.19
34	4.76	7.92	7.54	8.34	6.15	7.94	6.34	6.55	7.73	8.13
$V(Y)$	6.50	0.83	0.32	1.58	1.11	0.82	0.86	0.66	0.54	1.59

TABLE 2. UNBIASED ESTIMATES OF THE VARIANCES OF THE ESTIMATORS $\hat{Y}_1$, $\hat{Y}_2$, $\hat{Y}_3$, AND $\hat{Y}_4$ OBTAINED BY ESTIMATING Y^2 IN DIFFERENT WAYS

sample	$\hat{V}_1(\hat{Y}_1)$	$\hat{V}_2(\hat{Y}_1)$	$\hat{V}_3(\hat{Y}_1)$	$\hat{V}_4(\hat{Y}_1)$	$\hat{V}_1(\hat{Y}_2)$	$\hat{V}_2(\hat{Y}_2)$	$\hat{V}_3(\hat{Y}_2)$	$\hat{V}_4(\hat{Y}_2)$
12	106.75	114.35	113.69	114.84	−13.82	− 6.22	− 6.88	− 5.68
13	81.39	93.46	92.41	94.47	−16.76	− 4.69	− 5.74	− 3.68
14	62.93	79.04	78.05	80.33	−16.69	− 0.58	− 1.58	0.70
23	3.35	4.97	4.28	5.62	− 5.41	− 3.79	− 4.48	− 3.13
24	−10.09	−10.97	−11.12	−10.71	2.08	1.20	1.05	1.46
34	−26.71	−35.12	−34.13	−36.23	15.42	5.02	6.00	3.91

	$\hat{V}_1(\hat{Y}_3)$	$\hat{V}_2(\hat{Y}_3)$	$\hat{V}_3(\hat{Y}_3)$	$\hat{V}_4(\hat{Y}_3)$	$\hat{V}_1(\hat{Y}_4)$	$\hat{V}_2(\hat{Y}_4)$	$\hat{V}_3(\hat{Y}_4)$	$\hat{V}_4(\hat{Y}_4)$
12	− 6.78	0.82	0.16	1.36	−18.80	−11.19	−11.85	−10.66
13	−10.43	1.64	0.59	2.65	−22.23	−10.16	−11.21	− 9.15
14	−14.04	2.07	1.08	3.36	−20.80	− 4.70	− 5.69	− 3.41
23	− 0.81	0.81	0.12	1.46	− 9.49	− 7.87	− 8.56	− 7.22
24	1.41	0.54	0.39	0.80	1.99	1.11	0.97	1.38
34	7.49	− 0.91	0.07	− 2.02	20.26	11.86	12.84	10.75

From Table 1 and 2 we see that the estimator $\hat{Y}_3$ has the least variance and that the variance estimator $\hat{V}_3(\hat{Y}_3)$ has the least variability. Incidentally $\hat{V}_3(\hat{Y}_3)$ is the only non-negative variance estimator of all the unbiased variance estimators considered here.

The estimators $\hat{Y}_1$ to $\hat{Y}_{10}$ have also been studied for the following population, when 2 units are selected with probabilities proportional to x without replacement for estimating the population total Y.

unit	u_1	u_2	u_3	u_4
x	2	2	4	6
y	2	6	6	10

This population has been considered by Goodman and Hartley (1958).

TABLE 3. ESTIMATES FOR ALL POSSIBLE SAMPLES OF 2 UNITS IN CASE OF DIFFERENT ESTIMATORS AND THEIR VARIANCES

sample	$\hat{Y}_1$	$\hat{Y}_2$	$\hat{Y}_3$	$\hat{Y}_4$	$\hat{Y}_5$	$\hat{Y}_6$	$\hat{Y}_7$	$\hat{Y}_8$	$\hat{Y}_9$	$\hat{Y}_{10}$
12	56.02	24.18	28.00	21.28	42.01	24.64	40.10	38.65	26.09	22.73
13	25.47	16.12	17.82	14.61	21.64	16.22	20.80	20.04	16.97	15.37
14	22.41	19.50	19.60	19.11	21.00	19.35	20.96	20.76	19.50	19.31
23	38.20	28.22	30.55	26.21	34.37	28.38	33.21	32.21	29.38	27.21
24	29.88	31.60	30.80	31.87	18.34	31.34	30.74	30.88	31.20	31.73
23	13.82	23.54	22.30	24.90	18.06	23.60	18.68	19.36	22.92	24.22
$\hat{V}(Y)$	116.81	22.35	22.07	25.73	49.70	21.89	42.99	37.53	21.47	23.59

From Table 3 we see that though $\hat{Y}_3$ has the least variance of the four estimators generated by the technique, some of the combinations of these estimators might be more efficient.

Case (ii) : *pps and srs of the remaining.* Suppose one unit is selected with probability proportional to a given measure of size in the first draw and the other unit is selected with equal probability without replacement in the second draw. Then the estimators corresponding to (7.6) to (7.9) are given by

$$\hat{Y}_1 = \hat{Y}_3 = \frac{y_i+y_j}{p_i+p_j}, \qquad \ldots \ (7.21)$$

$$\hat{Y}_2 = \frac{y_i}{\pi_i}+\frac{y_i}{\pi_j}, \quad \pi_i = p_i+\frac{1-p_i}{N-1}, \qquad \ldots \ (7.22)$$

$$\hat{Y}_4 = \frac{(N-1)}{p_i+p_j}\left[y_i\frac{p_j}{1-p_i}+y_i\frac{p_i}{1-p_j}\right], \qquad \ldots \ (7.23)$$

since

$$P(s) = (p_i+p_j)/(N-1), \qquad N(s \supset i) = (N-1),$$

$$P(s/i1) = 1/(N-1), \qquad P(s/i2) = p_j/(1-p_i).$$

Of these estimators only (7.21) satisfies the desirable condition mentioned in (4.7), for when we substitute p_i for y_i in (7.21), we get 1.

Case (iii) : *srs and pps of the remaining.* For the sake of completeness let us consider the case where one unit is selected with equal probability and then another unit is selected with probability proportional to a given measure of size without replacement. In this case we get

$$P(s) = \frac{1}{N}\left(\frac{p_i}{1-p_j}+\frac{p_j}{1-p_i}\right),$$

$$N(s \supset i) = (N-1), \qquad \pi_i = \sum_{j \neq i} P(s),$$

$$P(s/i1) = \frac{p_j}{(1-p_i)}, \qquad P(s/i2) = \frac{1}{N}\,\frac{p_i}{1-p_j}\,\frac{1}{\pi_i-1/N}.$$

The estimators in this case are

$$\hat{Y}_1 = \frac{(y_i+y_j)}{(N-1)\,P(s)} \qquad \ldots \quad (7.24)$$

$$\hat{Y}_2 = \frac{y_i}{\pi_i}+\frac{y_j}{\pi_j} \qquad \ldots \quad (7.25)$$

$$\hat{Y}_3 = N\,\frac{y_ip_j(1-p_j)+y_jp_i(1-p_i)}{p_i(1-p_i)+p_j(1-p_j)} \qquad \ldots \quad (7.26)$$

$$\hat{Y}_4 = \frac{\dfrac{y_i}{\pi_i-1/N}\,p_i(1-p_i)+\dfrac{y_i}{\pi_j-1/N}\,p_j(1-p_j)}{p_i(1-p_i)+p_j(1-p_j)} \qquad \ldots \quad (7.27)$$

None of the above estimators satisfies the desirable condition (4.7).

In all the above three cases, an unbiased estimator of the population variance σ^2 is given by

$$\frac{(y_i-y_j)^2}{N^2\pi_{ij}} \qquad \ldots \quad (7.28)$$

Series of estimators. In the general case of sampling n units with varying probabilities without replacement, the estimators corresponding to those considered above for the particular case of $n = 2$ can be written down. Of course, the expressions for the estimators in the general case would be rather complicated in many cases. It is of interest to note that the unordered estimator corresponding to the ordered estimator proposed by Des Raj in sampling with probability proportional to a given measure of size without replacement turns out to be

$$\hat{Y}_3 = \sum_{i=1}^{n} y_iP(s/i1)/P(s).$$

Since the population total Y can be expressed as

$$Y = \frac{1}{\binom{N-1}{m-1}}\,\Sigma_m(y_{i_1}+y_{i_2}+\ldots+y_{i_m}),\ (m = 1, 2, \ldots, n),$$

where $(i_1, i_2, \ldots, i_m)$ stands for a specific combination of m units out of N units and Σ_m stands for summation over all combinations of m units of N units, we get the following unbiased estimator of Y based on a sample selected with probability proportional to size without replacement with the initial probabilities P_i $(i = 1, 2, \ldots, N)$,

$$\left.\begin{aligned}
z_1 &= \frac{\Sigma_1 y_i\, P(s/i)}{P(s)} \\
z_2 &= \frac{\Sigma_2 (y_{i_1} + y_{i_2})\, P(s/i_1 i_2)}{(N-1)(P(s)} \\
&\vdots \\
z_m &= \frac{\Sigma_m\, (y_{i_1} + y_{i_2} + \ldots, y_{i_m})\;\; P(s/i_1\, i_2 \ldots i_m)}{\binom{N-1}{m-1} P(s)} \\
z_n &= \frac{y_{i_1} + y_{i_2} + \cdots + y_{i_m}}{\binom{N-1}{n-1} P(s)}
\end{aligned}\right\} \qquad \ldots \quad (7.29)$$

where $P(s/i_1\, i_2, \ldots, i_m)$, $(m = 1, 2, \ldots, n)$, stands for the conditional probability of getting the sample 's' given that the units $(i_1, i_2, \ldots, i_m)$ have already been selected in the first m draws.

It may be noted that these estimators are functions of the observations and the initial probabilities of selection of the units in the sample only and hence will be easier to calculate. These estimators have been arrived at by considering the generating event that a given set of m units $(m = 1, 2, \ldots, n)$ has occurred first in the sample.

Taking the generating event as the occurrence of a given set of m units in the sample irrespective of the order of selection, we get the following estimators.

$$\left.\begin{aligned}
z_1' &= \Sigma_1\, \frac{y_{i_1}}{\pi_{i_1}} \\
z_2 &= \frac{1}{N-1}\, \Sigma_2\, \frac{y_{i_1}\, y_{i_2}}{\pi_{i_1 i_2}} \\
&\vdots \\
z_m' &= \frac{1}{\binom{N-1}{m-1}}\, \Sigma_m\, \frac{y_{i_1} + y_{i_2} + \ldots + y_{i_m}}{\pi_{i_1 i_2 \cdots i_m}} \\
&\vdots \\
z_n' &= \frac{1}{\binom{N-1}{n-1}}\, \frac{y_{i_1} + y_{i_2} + \ldots + y_{i_m}}{\pi_{i_1 i_2 \cdots\, i_m}}
\end{aligned}\right\} \qquad \ldots \quad (7.30)$$

Unlike the previous set of estimators, these are functions of not only the observations and the initial probabilities but also of the initial probabilities of all the units in the population and hence these are difficult to calculate in practice. It may be observed that the first estimator of this set is that given by Horvitz and Thompson (1952) and that the last estimator of these two sets are the same as that proposed by Midzuno (1950).

In sampling n units with probability proportional to a given measure of size without replacement, some of the possible unbiased estimators of the population variance σ^2 are given by

$$\hat{\sigma}_1^2 = \sum_{i=1}^{n} \sum_{j>i} \frac{(y_i - y_i)^2}{N^2 \binom{N-1}{n-1} P(s)} \qquad \ldots \quad (7.31)$$

$$\hat{\sigma}_2^2 = \sum_{i=1}^{n} \sum_{j>i} \frac{(y_i - y_j)^2}{N^2 \pi_{ij}} \qquad \ldots \quad (7.32)$$

$$\hat{\sigma}_3^2 = \sum_{i=1}^{n} \sum_{j>i} \frac{(y_i - y_j)^2 P(s/ij, 1)}{N^2 P(s)}. \qquad \ldots \quad (7.33)$$

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ASSESSMENT AND CONTROL OF NON-SAMPLING ERRORS IN CENSUSES AND SURVEYS

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SUMMARY. A comprehensive treatment of the theory of non-sampling errors is given in this paper by bringing together the work of a number of authors on this subject. Various aspects of the problem of non-sampling errors such as sources of non-sampling errors, non-sampling bias and variation, use of the technique of interpenetrating sub-samples and non-response have been discussed. It may be noted that the derivation of a number of results in this field has been considerably simplified by the use of the conditional approach.

1. SOURCES OF NON-SAMPLING ERRORS

Till recently the theory of sampling has been developed assuming that each unit in the population has a unique 'true' value and that it can be observed and tabulated without introducing any error. This would mean that a complete enumeration of all the units in the population would give us figures without any errors, which is not usually the case, since in practice there are bound to be some observational and tabulation errors in the final results. Of course, in some cases these errors may be negligible in the context of the use to which the results are to be put. Even the first part of the assumption that each unit has a unique true value is questionable. As these types of errors are different from the error due to sampling of units and are due to sources other than sampling of units they are termed 'non-sampling errors' or 'response errors'.

The broad sources of non-sampling errors, which are present in both complete enumeration and sample survey, though possibly to varying degrees, are incomplete coverage of the population or sample (including non-response), faulty definitions, defective methods of data collection and tabulation errors. In case of sample surveys, the errors may also arise from defective sampling frame and selection procedures. More specifically the non-sampling errors may arise due to omission or duplication of units, inaccurate and inappropriate methods of measurement, inappropriate arrangement or wording of questions, inadequate and ambiguous instructions, non-response, deliberate or unconscious misreporting of data by respondents, carelessness on the part of the investigators and clerks, lack of proper supervision, and defective methods of scrutiny and tabulation of data.

From what has been stated above, it is clear that the results of sample surveys are subject not only to sampling error but to non-sampling errors also. In many situations the non-sampling errors may even be larger and therefore more important than the sampling error. Though data obtained on the basis of a complete enumeration are free from sampling error, they are subject to non-sampling errors. To make the results of censuses and surveys useful, it is necessary to reduce the non-sampling errors as much as possible. It may be noted that while, in general, sampling error decreases with increase in sample size, the non-sampling errors tend to increase with the sample size.

The question of assessment and control of non-sampling errors has been receiving considerable attention and suitable techniques are being developed for this purpose. Mahalanobis (1940, 1944, 1946), Mahalanobis and Lahiri (1961) and Lahiri (1957a,b) have given many important techniques for assessing and controlling errors in censuses and surveys. Hansen and others (1946, 1951, 1961) and Sukhatme and Seth (1952) have considered in detail the question of non-sampling errors and have developed a suitable mathematical model for it. Post-enumeration checks and re-interview surveys are being made part of some of the nation-wide censuses and surveys so as to enable assessment of non-sampling errors.

2. CONCEPTUAL SET-UP

The difference between the sample survey estimate and the parameter true value being estimated may be termed 'error'. If the units in the sample can be observed and tabulated accurately then this error consists of only the error due to sampling, namely, 'sampling error'. A measure of the sampling error is supplied by the mean square error which is the expected value of the square of the difference between the estimator and the true value. This mean square error is composed of two parts—'sampling bias' and 'sampling variance'. The former has been defined as the difference between the expected value of the estimator and the true value and the latter is a measure of the divergence of the estimator from its expected value. Of course, in some cases the sampling bias may be negligible or zero.

If the data are also subject to non-sampling errors, then the difference between a survey estimate and the parameter true value may be termed 'total error' and this consists of both sampling and non-sampling errors. In this section a conceptual set-up is developed, which would enable us to get a measure of the non-sampling errors in terms of 'non-sampling bias' and 'non-sampling variance'.

The 'true' value of a unit is to be conceived of as a characteristic of the unit independent of the survey conditions which may affect the value 'reported' for that unit. For instance, age of a person at a particular point of time, income of a person during a particular period of time and number of persons in a country at a point of time are examples of characteristics for which the true value exists and is clearly defined. There are many items of information, such as intelligence of a person, attitude to some social measures, consumer preference to certain articles, for which it is very difficult even to conceive of the true value. In such cases some suitable conceptually, defined value, which has to be to some extent arbitrary, may be taken as the true value. For the definition of a true value to be useful in practice, it should serve the purpose of the survey and it should be well defined and observable under 'reasonable conditions of survey' relating to subject coverage, method of enquiry, survey period and method of tabulation.

The non-sampling errors arise due to the fact that it may not be possible to collect and process data accurately even if the true value is well defined because of so many operational difficulties.

Suppose a sample has been chosen to be canvassed under reasonable conditions of survey and that there are two populations, one of investigators and the other of tabulators (clerks) qualified for doing the field and the processing work respectively of the same survey. If we repeatedly carry out the survey on the selected units with different samples of investigators and computors chosen with some suitable probability designs, we may get different results because of the various possible sources of error present under the usual operational conditions. Here there are three stages of randomization—selection of units, investigators and computors. The difference between the expected value of the estimator taken over all the three stages of randomization and the true value may be termed 'total bias'. This consists of both 'sampling bias' and 'non-sampling bias'. The variance of the estimator taken over all the three stages of randomization measures the divergence of the estimator from its expected value and consists of sampling variance, variance between investigators, variance between computors and some interactions between the three sources of error. For instance, the data collected by one investigator may be affected by his misunderstanding of the instructions, his preconceived notions about the survey, the earlier units canvassed by him etc. Thus we see that the total error consists of sampling bias and variance, non-sampling or response bias and variance and some interactions between the sample and the sources of non-sampling errors.

3. NON-SAMPLING BIAS

For the sake of simplicity, let us assume only two stages of randomization ; one for selecting the sample of units and the other for selecting the survey personnel instead of the three stages of randomization considered earlier. Here we consider the survey personnel as a whole instead of as investigators and computors. Let $\hat{Y}_{sr}$ be the estimate for the s-th sample of units supplied by the r-th sample of the survey personnel. The conditional expected value of $\hat{Y}_{sr}$ taken over the second stage of randomization for a fixed sample of units is given by

$$E_r(\hat{Y}_{sr}) = \hat{Y}_{s\cdot}, \qquad \dots \quad (3.1)$$

which may be different from the estimate $\hat{Y}_s$ based on the true values of the units in the sample. The expected value of this $\hat{Y}_s$, over the first stage of randomization gives

$$E_s(\hat{Y}_{s\cdot}) = Y', \qquad \dots \quad (3.2)$$

which is the value that can be unbiasedly estimated by the specified survey process. This value Y' may be different from the true population total Y and the difference

$$B(t) = Y' - Y \qquad \dots \quad (3.3)$$

may be termed the 'total bias'.

It may be noted that the sampling bias is given by

$$B(s) = E_s(\hat{Y}_s) - Y, \qquad \dots \quad (3.4)$$

which is the difference between the expected value of the estimator based on the true values and the true value of the population total. Since the total bias is the sum of sampling and non-sampling biases, the non-sampling or response bias is given by

$$B(r) = B(t) - B(s) = Y' - E_s(\hat{Y}_s) = E_s(\hat{Y}_{s\bullet} - \hat{Y}_{.s}) \qquad \dots \quad (3.5)$$

which is the expected value of the non-sampling or response deviation for the s-th sample. If it is a complete enumeration, there is no sampling bias and the total bias consists of only the response bias. In case of many sample surveys also, the total bias consists of only the response bias, since usually unbiased estimators (from the point of view of sampling of units) are used.

To fix the ideas let us consider an example where a simple random sample of n units is drawn without replacement from a population of N units and surveyed by k persons chosen with equal probability from a large population of K persons qualified for this work, each person surveying m of the units assigned to him at random $(n = mk)$. Let y_{sij} be the value reported by the j-th investigator for the i-th unit allotted to him in the s-th sample. Then an estimator of the population total is given by

$$\hat{Y} = \frac{N}{n} \sum_{j}^{k} \sum_{i}^{m} y_{sij} \,. \qquad \dots \quad (3.6)$$

The conditional expected value over all possible samples of investigators where the s-th sample is fixed is

$$E(\hat{Y}/s) = \frac{N}{n} \sum_{i}^{n} y_{si\bullet}\,, \quad (n = mk),\ y_{si\bullet} = \frac{1}{K} \sum_{j}^{K} y_{sij} \,.$$

If there were no non-sampling errors in the survey, the estimator would be

$$\hat{Y} = \frac{N}{n} \sum_{i}^{n} y_i \,,$$

where y_i is the true value. The difference

$$d_{si} = y_{si.} - y_i \qquad \dots \quad (3.7)$$

may be considered to be the 'response deviation'. This deviation may also depend on the particular sample being surveyed because of the possible influence of some units on those of the others in the sample. The response bias in this case is given by

$$B(r) = Y' - Y \qquad \dots \quad (3.8)$$

where

$$Y' = \frac{1}{\binom{N}{n}} \frac{N}{n} \sum_{i}^{N} \sum_{s \supset i} Y_{si\bullet}\,,$$

$\sum_{s \supset i}$ standing for the summation over all samples containing the i-th unit. If the average response for a unit is not affected by that of another unit in the sample, i.e., if $y_{si.} = y'_i$, then

$$Y' = \sum_{i}^{N} Y'_i, \left(Y'_i = \frac{1}{K} \sum_{j}^{K} Y_{ij} \right). \qquad \dots \quad (3.9)$$

There are a number of techniques available for the assessment of response bias (Lahiri, 1957a, 1957b). The survey figure may be compared with an external figure obtained by some other agency or by the same agency in some previous period after making the necessary adjustments for differences in coverage, definitions, survey period etc. This comparison may be taken as a broad check of the survey figure. This check is termed 'external aggregative check'. A better check would be to have unit by unit comparison of the survey data with the corresponding values in some other survey. This method is termed 'external unitary check'. It may be noted that there would be considerable difficulties in matching the units for this type of check. In these checks the assumption is that one source of data is more reliable than the other. If this assumption is not ture, it would be difficult to conclude which figure is subject to more bias in case of discrepancies. Another technique of assessing response bias is to draw the sample in the form of two or more interpenetrating sub-samples and to get these surveyed by different groups of investigators. This procedure is known as the method of interpenetrating sub-samples and will be considered in detail in Section 10.

The response bias in a census can be estimated by surveying a sample of units in the population using better techniques of data collection and compilation than would be possible under census conditions. Such surveys which are usually conducted just after the census to study the quality of the census data are called 'post-enumeration surveys'. Even in case of a large scale sample survey, the response bias can be estimated by resurveying a sub-sample of the original sample using better survey techniques. Another method of checking survey data would be to compare the values of the units obtained in two surveys and to reconcile the figures by further investigation in case of discrepancies. This method of checking is termed 'reconciliation (check) surveys.

4. Non-sampling variance

The mean square error of the estimator $\hat{Y}_{sr}$, based on the s-th sample of units and supplied by the r-th sample of the survey personnel, is by definition

$$M(\hat{Y}_{sr}) = E_{sr}(\hat{Y}_{sr} - Y)^2 \qquad \dots \quad (4.1)$$

where Y is the true value being estimated. This is a measure of the divergence of the estimator from the true value, taking into account both sampling and non-sampling errors. This measure consists of bias and variance, that is,

$$\begin{aligned} M(\hat{Y}_{sr}) &= V(\hat{Y}_{sr}) + B^2(\hat{Y}_{sr}) \\ &= E(\hat{Y}_{sr} - Y')^2 + (Y' - Y)^2 \end{aligned} \qquad \dots \quad (4.2)$$

where Y' is the expected value of the estimator taken over both the stages of randomization. The variance of the estimator is a measure of the divergence of the estimator from its expected value and $Y'-Y$ is the bias. Taking the variance over the two stages of randomization, we get

$$\begin{aligned} V_{sr}(\hat{Y}_{sr}) &= V_s E_r(\hat{Y}_{sr}) + E_s V_r(\hat{Y}_{sr}) \\ &= V_s(\hat{Y}_{s.}) + E_s E_r(\hat{Y}_{sr} - \hat{Y}_{s.})^2. \qquad \ldots \quad (4.3) \end{aligned}$$

From (4.3) we see that the variance can be split up into two parts—sampling variance and response variance. The second term stands for the expected value of the square of the response deviations of the sample estimates from their expected value taken over both the stages of randomization. This term can be further split up by writing

$$\hat{Y}_{sr} - \hat{Y}_s = (\hat{Y}_{sr} - \hat{Y}_s - \hat{Y}_{.r} + Y') + (\hat{Y}_{.r} - Y')$$

where $\hat{Y}_{.r} = E_s(\hat{Y}_{sr})$, and taking the variance we get

$$E_{sr}(\hat{Y}_{sr} - \hat{Y}_{s.})^2 = E_{sr}(\hat{Y}_{sr} - \hat{Y}_{s.} - \hat{Y}_{.r} + Y')^2 + E_r(\hat{Y}_{.r} - Y')^2. \qquad \ldots \quad (4.4)$$

The first term on the right in (4.4) is the interaction between the sampling and non-sampling errors and the second term is the variance between survey personnel. Thus we see that the mean square of the estimator consists of sampling variance, interaction between sampling and non-sampling errors, variance between survey personnel and square of sum of the sampling and non-sampling biases. In a complete census the mean square error is composed of only the non-sampling variance and square of the response bias.

5. SIMPLE RANDOM SAMPLING

To fix the ideas let us consider the case where a simple random sample of n units drawn with replacement from a population of N units is divided at random into k equal sub-samples of m units each and these sub-samples are surveyed by k investigators selected with equal probability from a large population of K investigators qualified for this work. Let Y_{ij} and Y_i be the value reported by the j-th investigator for the i-th unit in the population and its true value respectively. Suppose y_{ij} is the value reported for the i-th unit in the sample by the j-th selected investigator. Here it is assumed that the response for a unit is not affected by the response of other units in the sample. An estimator of the population mean is given by

$$\bar{y} = \frac{1}{n} \sum_{j}^{k} \sum_{i}^{m} y_{ij}, \qquad (n = km). \qquad \ldots \quad (5.1)$$

The expected value of the estimator taken over the two stages of randomization is

$$\begin{aligned} E(\bar{y}) &= \frac{1}{N} \sum_{i}^{N} Y'_i, \left(Y'_i = \frac{1}{K} \sum_{j}^{K} Y_{ij} \right) \qquad \ldots \quad (5.2) \\ &= \bar{y}' \end{aligned}$$

and the total bias, which in this case consists wholly of response bias, is

$$B(t) = B(r) = \frac{1}{N} \sum_{i}^{N} (Y'_i - Y_i). \qquad \ldots \quad (5.3)$$

The variance of the estimator is given by

$$V_{sr}(\bar{y}) = V_s E_r(\bar{y}) + E_s V_r(\bar{y})$$

where the subscripts denote the stages of randomization. The conditional expected value of $\bar{y}$ over the second stage of randomization for a fixed sample of units is

$$E_r(\bar{y}) = \frac{1}{n}\sum_{i}^{n} y'_i, \left(y'_i = \frac{1}{K}\sum_{j}^{K} y_i \right).$$

The unconditional variance of this over the first stage of randomization is given by

$$V_s E_r(\bar{y}) = \frac{\sigma_s^2}{n}, \qquad \sigma_s^2 = \frac{1}{N}\sum_{i}^{N} (Y'_i - \bar{Y}')^2. \qquad \dots (5.4)$$

The conditional variance of $\bar{y}$ over the second stage of randomization for a fixed sample of units is

$$V_r(\bar{y}) = \frac{1}{k} E_r \left(\frac{1}{m}\sum_{i}^{m} y_{ij} - \frac{1}{m}\sum_{i}^{n} y'_i \right)^2$$

$$= \frac{1}{km^2}\frac{1}{K}\sum_{j}^{K}\left[\sum_{i}^{m} (y_{ij} - y'_i)^2 + \sum_{i}^{m}\sum_{i' \neq i} (y_{ij} - y'_i)(y_{i'j} - Y'_{i'}) \right]$$

for $V_r\left(\frac{1}{m}\sum_{i}^{m} y_{ij}\right)$ is the same for all j. Taking the unconditional expected value of this expression over the first stage of randomization, we get

$$E_s V_r(\bar{y}) = \frac{1}{km^2}\frac{1}{K}\sum_{j}^{K}\left[\frac{m}{N}\sum_{i}^{N} (Y_{ij} - Y'_i)^2 + \frac{m(m-1)}{N(N-1)}\sum_{i}^{N}\sum_{i' \neq i} (Y_{ij} - Y'_i)(Y_{i'j} - Y'_{i'}) \right.$$

$$= \frac{1}{km}\sigma_d^2 [1 + (m-1)\rho], \qquad \dots (5.5)$$

where σ_d^2 is termed 'simple' or 'uncorrelated' response variance and is given by the variance of individual response deviations, that is,

$$\sigma_d^2 = \frac{1}{KN}\sum_{i}^{N}\sum_{j}^{K} (Y_{ij} - Y'_i)^2 \qquad \dots (5.6)$$

and ρ is the intra-class correlation among the response deviations in a sample canvassed by one investigator (intra-investigator correlation), and is given by

$$\rho\,\sigma_d^2 = \frac{1}{KN(N-1)}\sum_{j}^{K}\sum_{i}^{N}\sum_{i' \neq i} (Y_{ij} - Y'_i)(Y_{i'j} - Y'_{i'}). \qquad \dots (5.7)$$

Hence the variance and the mean square error of $\bar{y}$ are

$$V(\bar{y}) = \frac{\sigma_s^2}{n} + \frac{\sigma_d^2}{n}[1 + (m-1)\rho] \qquad \dots (5.8)$$

$$\text{m.s.e.}(\bar{y}) = V(\bar{y}) + (\bar{Y}' - \bar{Y})^2. \qquad \dots (5.9)$$

and

In case of a complete census, sampling variance would be zero and hence the variance and mean square error of the census figure $\bar{y}'$ are given by

$$V(\bar{y}') = \frac{\sigma_d^2}{N}\,[1+(m-1)\rho] \qquad \ldots \quad (5.10)$$

$$\text{m.s.e. } (\bar{y}') = V(\bar{y}')+(\overline{Y}'-\overline{Y})^2 \qquad \ldots \quad (5.11)$$

The result in (5.8) shows the contribution to the total variance from the response variation and it also brings out the impact of the intra-class correlation among the responses in a sample canvassed by one investigator (intra-investigator correlation) on the response variance. The intra-class correlation will be positive if the response deviations for the different units have a consistent tendency to be in one direction for an investigator and in another direction for another investigator. Even when this correlation is small, the contribution to the response variation may be considerable if m, the number of units surveyed by each investigator is large. For instance, if $\rho = 0.01$ and $m = 1000$, the response variation becomes about ten times more than that in case of $\rho = 0$.

An unbiased estimator of the variance of the estimator $\bar{y}$ given in (5.8) is given by

$$\hat{V}(\bar{y}) = \frac{1}{k(k-1)} \sum_j^k (\bar{y}_{\bullet j}-\bar{y})^2, \qquad \left(\bar{y}_{\bullet j} = \frac{1}{m} \sum_j^m y_{ij} \right) \qquad \ldots \quad (5.12)$$

for $$E\left(\sum_j^k \bar{y}_{\bullet j}^2 - k\bar{y}^2 \right) = k[kV(\bar{y})+\overline{Y}'^2-V(\bar{y})-\overline{Y}'^2] = k(k-1)\; V(\bar{y}).$$

This result shows that if k independent samples are surveyed by k investigators selected with equal probability from a large population of investigators, then it is possible to get an unbiased estimator of the total variance (and not the total mean square error). This procedure is known as the method of 'interpenetrating sub-samples' which is considered in detail in Section 10. The variance between investigators is given by

$$\sigma_r^2 = \frac{1}{K} \sum_j^K (\overline{Y}'_{\bullet j}-\overline{Y}')^2 \doteq \sigma_d^2\, \rho \qquad \ldots \quad (5.13)$$

for $$\sigma_r^2 = \frac{1}{K} \sum_j^K \left[\frac{1}{N} \sum_i^N (Y_{ij}-Y'_i) \right]^2$$

$$= \frac{1}{KN^2} \sum_j^K \sum_i^N (Y_{ij}-Y'_i)^2 + \frac{1}{KN^2} \sum_j^K \sum_i^N \sum_{i' \neq i} (Y_{ij}-Y'_i)(Y_{i'j}-Y'_{i'})$$

$$= \frac{\sigma_d^2}{N} + \frac{N-1}{N}\; \sigma_d^2 \rho \doteq \sigma_d^2 \rho.$$

if N is assumed to be large. An unbiased estimator of σ_r^2 is given by

$$\hat{\sigma}_r^2 = k\hat{V}(\bar{y}) - \frac{1}{km(m-1)} \sum_j^k \sum_i^m (y_{ij}-\bar{y}_{\bullet j})^2, \qquad \ldots \quad (5.14$$

for taking the conditional expected value of the second term in (5.14), we get

$$\frac{1}{mk}\sum_{j}^{k}\frac{1}{N}\sum_{i}^{N}(Y_{ij}-\overline{Y}'_{\cdot j})^2$$

and the expected value of this expression over the sample of investigators, is given by

$$\frac{1}{m}\;\frac{1}{NK}\sum_{j}^{K}\sum_{i}^{N}(Y_{ij}-\overline{Y}'_{\cdot j})^2=\frac{1}{m}\,(\sigma^2-\sigma_r^2),$$

where σ^2 is the total variance in the population and is given by

$$\sigma^2=\frac{1}{KN}\sum_{j}^{K}\sum_{i}^{N}(Y_{ij}-\overline{Y}')^2=\sigma_s^2+\sigma_d^2. \qquad \dots \quad (5.15)$$

Hence

$$E(\hat{\sigma}_r^2)=k\left[\frac{\sigma^2}{mk}+\frac{(m-1)}{mk}\,\sigma_r^2\right]-\frac{1}{m}\,(\sigma^2-\sigma_r^2)=\sigma_r^2.$$

6. Estimation of population proportion

It is interesting to consider the question of response variance in estimating a population proportion. Let Y_{ij} be 1 or 0 according as the j-th investigator reports the i-th unit in the population as belonging to a particular class or not and let P'_i be the proportion of the investigators reporting the i-th unit in the population as belonging to that class. Suppose a simple random sample of n units is drawn with replacement from a population of N units to be surveyed by a sample of k persons selected with equal probability from a large population of K persons qualified for this work. An estimator of the population proportion P is given by

$$\hat{P}=\frac{1}{mk}\sum_{j}^{k}\sum_{i}^{m}y_{ij}\quad (n=mk) \qquad \dots \quad (6.1)$$

where y_{ij} is 1 or 0 according as the j-th selected investigator reports the i-th unit in the sample as belonging to a given class or not. The expected value of this estimator over both the stages of randomization is

$$E(\hat{P})=\frac{1}{N}\sum_{i}^{N}P'_i=P' \qquad \dots \quad (6.2)$$

and the bias, which in this case consists of only the response bias, is $P'-P$. In this case σ_s^2 and σ_d^2 defined in (5.4) and (5.6) respectively are given by

$$\sigma_s^2=\frac{1}{N}\sum_{i}^{N}(P'_i-P')^2 \qquad \dots \quad (6.3)$$

and

$$\sigma_d^2=\frac{1}{N}\sum_{i}^{N}P'_iQ'_i,\quad (Q'_i=1-P'_i). \qquad \dots \quad (6.4)$$

The variance of $\hat{P}$ is

$$V(\hat{P})=\frac{1}{Nn}\sum_{i}^{N}(P'_i-P')^2+\frac{1}{Nn}\sum_{i}^{N}P'_iQ'_i\;[1+(m-1)\rho]. \qquad \dots \quad (6.5)$$

From (5.12) it can be seen that an unbiased estimator of the total variance given in (6.5) is

$$\hat{V}(\hat{P}) = \frac{1}{k(k-1)} \sum_{j}^{k} (p_{\cdot j} - p)^2 \tag{6.6}$$

where $p_{\cdot j}$ is the sample proportion reported by the j-th selected investigator in the sample assigned to him and p is the over-all sample proportion. From (5.14), an unbiased estimator of the variance between investigators σ_r^2 is given by

$$\hat{\sigma}_r^2 = \hat{V}(\hat{P}) - \frac{1}{m(m-1)k} \sum_{j}^{k} p_{\cdot j} q_{\cdot j} \quad (q_{\cdot j} = 1 - p_{\cdot j}). \qquad \dots \quad (6.7)$$

If the intra-clas correlation is assumed to be 0, then the variance given in (6.5) reduces to

$$V(\hat{P}) = \frac{P'Q'}{n}, \quad (Q' = 1 - P'). \qquad \dots \quad (6.8)$$

This result is interesting because it shows that the expression which is normally used as the sampling variance of a sample proportion includes not only the sampling variance but also the uncorrelated response variance (Hansen, Hurwitz and Bershad, 1961). An unbiased estimator of the variance is

$$\hat{V}(\hat{P}) = \frac{pq}{(n-1)}, \quad (q = 1 - p) \qquad \dots \quad (6.9)$$

since $E(pq) = E(p) - E(p^2) = P' - V(p) - P'^2 = (n-1)V(p)$. Here again we see that the variance estimator of a sample proportion usually used to estimate the sampling variance estimates unbiasedly the total variance including both the sampling variance and the uncorrelated response variance.

7. COST FUNCTION

Let us consider the case of getting optimum values of k, the number of investigators, and m, the number of units assigned to each investigator, which would minimize the total variance for a given fixed cost. Suppose the cost function

$$C = kC_1 + nC_2 \qquad \dots \quad (7.1)$$

where C_1 is the cost of recruiting and training one investigator, C_2 is the cost of surveying one unit and $n = km$. The total variance of the estimator $\bar{y}$ of the population mean $\bar{Y}$, given in (5.8), may be written as

$$V(\bar{y}) = \frac{\sigma^2 - \sigma_r^2}{n} + \frac{\sigma_r^2}{k} \qquad \dots \quad (7.2)$$

where $\sigma_r^2 = \rho\sigma_d^2$ and $\sigma^2 = \sigma_s^2+\sigma_d^2$. Minimizing the variance in (7.2) with respect to n and k subject to the cost restriction (7.1), we get

$$k = \frac{C}{\sqrt{C_1\sigma_r^2}+\sqrt{C_2(\sigma^2-\sigma_r^2)}}\sqrt{\left(\frac{\sigma_r^2}{C_1}\right)} \qquad \dots \quad (7.3)$$

$$m = \frac{C_1}{C_2}\sqrt{\frac{\sigma^2-\sigma_r^2}{\sigma_r^2}}. \qquad \dots \quad (7.4)$$

8. INTRA-INVESTIGATOR CORRELATION

A number of empirical studies have been conducted in recent years to assess the magnitude of the intra-investigator correlation coefficient for different types of characteristics. The results obtained in some of these studies are presented in Table 1.

TABLE 1. SHOWING THE RANGES OF THE INTRA-INVESTIGATOR CORRELATION COEFFICIENT FOR DIFFERENT TYPES OF CHARACTERISTICS

reference (1)	k^x (2)	type of items (3)	range of ρ (4)
Gray (1956)	20	8 factual items	0−0.02
		perception of and attitude to neighbour's noises	0−0.08
		8 items about illness	0−0.11
Gales and Kendall (1957)	48	most semi-factual and attitudinal items about TV habits	0−0.05
Hanson and Marks (1958)	705	most factual items	0.01−0.02
		more difficult items	0.02−0.04
		most 'not ascertained' categories	0.02−0.06
Kish and Slater (1960)	20	first study	0−0.07
	8	second study	0−0.04
Kish and Rangford (in preparation)	9	measurement of major dental defects	0.15−0.50

x : number of investigators

Source : Kish, L (1962) : Two studies of interviewer variance of socio-psychological variables. Presented at the Annual Meeting of the American Statistical Association.

9. NON-RESPONSE ERROR

One of the sources of error in censuses and surveys, mentioned earlier, is the incomplete coverage of the population or sample. This incomplete coverage may arise due to respondents' refusal to give information, respondents being 'not at home', inaccessible sample units etc. The error in this case arises because the population of non-respondents may have characteristics different from those who respond and the results based only on the surveyed units may be misleading. This type of error may be termed 'non-response error', since it arises from not surveying all the units in the population or sample. The non-response error may not be important if the units not responding in a survey have characteristics similar to those of the responding units. But usually in practice this situation does not arise. For instance, if questionnaires are mailed to a number of farmers, the non-response rate may not be uniform among the farmers having land-holdings of different sizes and hence the results based only on the responses of the responding farmers may be misleading. It may be noted that in most cases of non-response, the response may be obtained by persuasion, repeated visits to the non-responding units etc.

One way of dealing with the problem of non-response is to make all efforts to collect information from a sub-sample of the units not responding in the first attempt (Hansen and Hurtwitz, 1946). Suppose, out of n units selected with equal probability without replacement from a population of N units, n_1 units respond and $n_2(=n-n_1)$ units do not respond in the first attempt. Let a sub-sample of n_2' units be selected from the n_2 non-responding units with equal probability without replacement for making sepcial efforts to collect the information. If $\bar{y}_1$ and $\bar{y}_2'$ are sample means based on the n_1 units responding in the first attempt and on the sub-sample of n_2' units respectively, then an unbiased estimator of the population total Y is given by

$$\hat{Y} = \frac{N}{n}(n_1\bar{y}_1+n_2\bar{y}_2'). \qquad \ldots \quad (9.1)$$

It may be noted that there are three stages of randomization in this case; sampling of units, number of units in the sample not responding in the first attempt and sub-sampling of n_2' units from the n_2 units not responding in the first attempt. Taking the variance of the estimator given in (9.1) over these three stages of randomization, we have

$$V_{123}(\hat{Y}) = V_1E_2E_3(\hat{Y})+E_1V_2E_3(\hat{Y})+E_1E_2V_3(\hat{Y})$$

where E and V stand for conditional expected value and variance and the subscripts denote the stages of randomization. The conditional expected value and variance over the third stage of randomization are given by

$$E_3(\hat{Y}) = \frac{N}{n}(n_1\bar{y}_1+n_2\bar{y}_2) = N\,\bar{y}, \left(\bar{y}_2 = \frac{1}{n_2}\sum_{i}^{n_2} y_{2i}\right)$$

and $$V_3(\hat{Y}) = \frac{N^2}{n^2}\,n_2(n_2-n_2')\,\frac{s_2^2}{n_2'}, \quad s_2^2 = \frac{1}{(n_2-1)}\sum_{i}^{n_2}(y_{2i}-\bar{y}_2)^2,$$

where $\bar{y}$ is the sample mean based on all the n units in the sample and y_{2i} is the value of the i-th non-responding unit in the sample. Further it can be seen that

$$E_2(N\,\bar{y}) = N\,\bar{y} \text{ and } V_2(N\bar{y}) = 0.$$

Hence the variance of the estimator is given by

$$V(\hat{Y}) = V_1(N\bar{y})+E_1E_2\left[\frac{N^2}{n}\left(\frac{n_2}{n}\right)(k-1)\,s_2^2\right],$$

where $k = n_2/n_2'$. Since

$$E_1(s_2^2) = \frac{N_2}{N_2-1}\ \sigma_b^2 \text{ and } E_2\left(\frac{n_2}{n}\right) = \frac{N_2}{N},$$

where σ_b^2 is the variance between the units in the population not responding in the first attempt and N_2 is the number of such non-responding units in the population, the variance becomes

$$V(\hat{Y}) = \frac{N^2(N-n)}{(N-1)}\frac{\sigma^2}{n} + \frac{N}{n}(k-1)\frac{N_2^2\,\sigma_b^2}{(N_2-1)} \qquad \dots \quad (9.2)$$

where σ^2 is the variance between the N units in the population.

The cost function in this case may be of the form

$$C = C_1 n + C_2 nP + C_3 \frac{n}{k}\, Q \qquad \dots \quad (9.3)$$

where C_1 is the cost per unit for the first attempt at data collection, C_2 is the cost per unit for tabulation, C_3 is the cost per unit sampled from the non-responding units (for obtaining data by additional efforts and for tabulation), P is the proportion of units in the population that would have responded in the first attempt, and $Q = 1-P$. The optimum values of n and k which would minimize the cost, ensuring at the same time a given value V^2 for the variance of the estimator, are given by

$$n = \hat{n}\left[\ 1+(k-1)Q^2\frac{N-1}{N_2-1}\frac{\sigma_b^2}{\sigma^2}\right] \qquad \dots \quad (9.4)$$

$$k = \sqrt{\left[\frac{N^2(N_2-1)\sigma^2}{N_2^2(N-1)\sigma_b^2} - 1\right]\frac{C_3 Q}{C_1+C_2 P}}, \qquad \dots \quad (9.5)$$

where

$$\hat{n} = \frac{N\sigma^2}{\sigma^2 + \frac{N-1}{N^2}\,v^2},$$

the sample size required for ensuring the value v^2 for the variance if there were complete response. If it is assumed that $\sigma^2 = \sigma_b^2$ and $\frac{N}{N-1} \doteq \frac{N_2}{N_2-1} \doteq 1$, the optimum values of n and k reduce to

$$n = \hat{n}[1+(k-1)\,Q], \qquad \dots \quad (9.6)$$

$$k = \sqrt{\frac{C_3 P}{C_1+C_2 P}}.$$

An interesting device in dealing with 'not at home' cases has been considered by Politz and Simmons (1949). This procedure consists in ascertaining from the responding households the chance of their being at home at a particular point of time and weighting the results with the inverse of this chance. For instance, the households may be asked whether they were at home at some specified time during the previous

5 days. Then the households may be classified as being at home once in 6 visits, twice in 6 visits etc, and the data obtained for the different classes may be weighted by the inverse of the respective probabilities of being at home. In practice some bias would still persist because of persons not at home during the entire investigation period, who cannot be contacted.

10. INTERPENETRATING SUB-SAMPLES

The technique of interpenetrating sub-samples, which is due to Mahalanobis (1940, 1944, 1946), in its most general sense consists of drawing the sample in the form of k sub-samples according to any probability sampling design which would enable in getting valid estimates of the population parameter under consideration and subjecting these sub-samples to k different operations to study the differential effects of these operations. This technique has many possibilities in the field of censuses and survey sin assessing non-sampling error (Lahiri, 1953, 1957a, 1957b; Mahalanobis, 1956; Mahalanobis and Lahiri, 1961). One of the advantages has been mentioned in Section 5. There it was shown that if k independent interpenetrating sub-samples are drawn from a population of investigators, it would be possible to estimate the total variance of the estimator including both sampling and response variations.

Linked sub-samples. Originally, Mahalanobis (1940) made use of this technique in crop surveys to find out the differential investigator bias. For this purpose, linked pairs of grids (square parcel of land) were located at random on the maps in the form of dumb-bell shaped figures, one end of each figure representing the grid belonging to sub-sample 1 and the other end representing the grid belonging to sub-sample 2. One sub-sample was investigated by one set of investigators and the other sub-sample by an entirely different set of investigators independently. Under certain well-known assumptions Student's t-test may be applied to the difference between the estimates based on the two sub-samples to test the hypothesis that there is no differential investigator bias at any specified level of singificance. If the difference turns out to be significant, it means that the direction and magnitude of investigator bias are not of the same nature for all the investigators. It may be noted that if the difference turns out to be statistically insignificant, it does not mean that the investigator bias is zero. For, this result may be due to the fact that the biases are all of the same order and in the same direction.

The above method can well be applied to bring out the differential effect of different tabulation procedures, methods of data collection, etc., and to bring out the variation over time. Suppose one is interested in finding out whether intensive training of the investigators for a given survey is essential or not. For this purpose, one sub-sample may be assigned to intensively trained investigators and the other sub-sample to investigators who have got only superficial training. If the difference in the results obtained from these two sub-samples turns out to be significant, there is a strong case for adopting the method of intensive training in future surveys of a similar nature. On the other hand, if the difference were not significant, it would mean that for this type of survey intensive training is perhaps not essential.

The technique of interpenetrating sub-samples may be used as a check on the different operations involved in large scale surveys. Suppose one wishes to have a check on the calculations at the time of tabulation. For this purpose, the sample may be divided into k linked sub-samples assigned to k different groups of computors at random and the estimates may be obtained from each of these sub-samples. If there is good agreement between these estimates, for all practical purposes it may be assumed with certain amount of confidence that the calculations have been done correctly. If one of these estimates differs from the others (assuming k is more than 2) and if there is good agreement between the remaining $k-1$ estimates, one naturally suspects the calculations done on that sub-sample and gets that estimate recalculated. Thus it is seen that suitable action can be taken on the basis of the sub-sample estimates thereby increasing the accuracy and utility of the final results.

It is to be noted that detailed interpenetration of the sub-samples would require additional preparatory time and would increase the complexity of work at the field and the tabulation stages to some extent (Mokashi, 1950). It is also found that the power of the interpenetrating sub-sample check is generally low due to the fact that the estimate of variance usually used in the test is based only on a few degrees of freedom (Sukhatme and Seth, 1952). It may be noted that the larger the positive correlation between the sub-samples, the greater will be the sensitivity of the test and lower will be the efficiency of the joint estimate based on the sub-samples. So if the main object of the survey is to test the differential investigator bias, then it would be desirable to have the same sample investigated by both the sets of investigators independently under the same conditions. If this is not possible due to the presence of conditioning effect between successive investigations of the same unit, it would be desirable to use sub-samples which are linked in such a way that the estimates from these samples are highly correlated.

Independent sub-samples. As has already been pointed out, linked samples are to be used only if the main objective is to find out the differential effect of two operations. But if the main object is to get a reliable estimate of the population parameter and the study of differential effects is only a subsidiary objective, then it is preferable to have independent interpenetrating sub-samples. The difference between the estimates based on two independent interpenetrating sub-samples provide a measure of the sampling as well as non-sampling errors present in the results.

The technique of interpenetrating sub-samples is of help in calculating the-total variation especially in large scale sample surveys where a number of characteristics are under consideration. If there are k independent interpenetrating sub-samples subjected to k different operations each providing a valid estimate of the population parameter under consideration, then an unbiased estimator of the variance of the combined estimator (mean of the sub-sample estimates) is given by

$$\hat{V}(y) = \frac{1}{k(k-1)} \sum_{i}^{k} (y_i-\bar{y})^2, \quad (\bar{y} = \frac{1}{k} \sum_{i}^{k} y_i), \qquad \ldots \quad (10.1)$$

where y_i is the estimate based on the i-th sub-sample. It may be noted that this procedure gives a simple method of getting an estimator of the variance of a ratio estimator. If $r_i \left(=\frac{y_i}{x_i}\right)$, $(i = 1, 2, \ldots, k)$ is an estimate of the population ratio $R \left(=\frac{Y}{X}\right)$ based on the i-th sub-sample, then an unbiased estimator of the variance of

$$R' = \frac{1}{k} \sum_{i}^{k} r_i \qquad \ldots \quad (10.2)$$

is given by

$$\hat{V}(R') = \frac{1}{k(k-1)} \sum_{i}^{k} (r_i - R')^2. \qquad \ldots \quad (10.3)$$

Since the variance of R' and that of the combined ratio estimator

$$R'' = \frac{\sum\limits_{i}^{k} y_i}{\sum\limits_{i}^{k} x_i} \qquad \ldots \quad (10.4)$$

are approximately the same (Murthy and Nanjamma, 1959), (10.3) can be taken as an estimator of the variance of R''.

It is to be noted that the variance estimator given in (10.1) holds even if the variances of sub-sample estimates are different, provided the combined estimator is taken as the arithmetic mean of the sub-sample estimates. An unbiased estimator of variance can be obtained on the basis of independent interpenetrating sub-sample estimates even if the sub-sample estimates are weighted to obtain the combined estimator. If y_i and w_i are respectively the estimate and the weight for the i-th sub-sample $(i = 1, 2, \ldots, k)$, then an unbiased estimator of the variance of the combined estimator

$$\hat{Y} = \sum_{i}^{k} w_i y_i, \qquad \left(\sum_{i}^{k} w_i = 1\right) \qquad \ldots \quad (10.5)$$

is given by

$$\hat{V}(\hat{Y}) = \hat{Y}^2 - \frac{2}{1-\Sigma w_i^2} \sum_{i}^{k} \sum_{j>i} w_i w_j y_i y_j$$

since $E(\hat{Y}^2) = V(\hat{Y}) + Y^2$ and the second term in the above expression estimates unbiasedly Y^2. This expression after simplification becomes

$$\hat{V}(\hat{Y}) = \frac{(\Sigma w_i^2 y_i^2) - (\Sigma w_i^2)(\Sigma w_i y_i)^2}{(1-\Sigma w_i^2)}. \qquad \ldots \quad (10.6)$$

Since this estimator, may be difficult to compute in practice, the following unbiased variance estimator is suggested.

$$\hat{V}'(\hat{Y}) = \hat{Y}^2 - \frac{1}{\binom{k}{2}} \sum_{i=1}^{k} \sum_{j>i} y_i y_j = \hat{Y}^2 - \frac{1}{k(k-1)}\left[\left(\sum_{i=1}^{k} y_i\right)^2 - \sum_{i=1}^{k} y_i^2\right].$$

In case of $k = 2$ this becomes simply $\hat{V}(\hat{Y}) = \hat{Y}^2 - y_1 y_2$ which is quite simple to calculate since $\hat{Y}_1$, y_1 and y_2 would be readily available.

Suppose in a stratified sample design, there are k independent interpenetrating sub-samples in each stratum. Let y_{si} denote the estimate of the s-th stratum total based on the i-th sub-sample ($s = 1, 2, \ldots, L$; $i = 1, 2, \ldots, k$). The variance estimator based on sub-sample estimates may be obtained either using strata sub-sample estimates or just the sub-sample estimates pooled over the strata. That is

$$\hat{V}_1(\hat{Y}) = \frac{1}{k(k-1)} \sum_{s}^{L} \sum_{i}^{k} (y_{si} - \bar{y}_{s\cdot})^2 \qquad \ldots \quad (10.7)$$

$$\hat{V}_2(\hat{Y}) = \frac{1}{k(k-1)} \sum_{i}^{k} (y_{\cdot i} - \bar{y})^2 \qquad \ldots \quad (10.8)$$

where $\bar{y}_{s\cdot} = \frac{1}{k} \sum_{i}^{k} y_{si}$, $y_{\cdot i} = \sum_{s}^{L} y_{si}$ and $\bar{y} = \frac{1}{k} \sum_{i}^{k} y_{\cdot i}$.

Of these two estimators (10.7) is more efficient than (10.8) (Murthy, 1962), though the calculation of the latter will be less time consuming than that of the former. In a stratified sample design with k independent interpenetrating sub-samples, if y_{si} and x_{si} denote the estimates of the s-th stratum total for the characteristics y and x respectively based on the i-th sub-sample, then an estimator of the variance of the ratio estimator $\hat{R}(=\bar{y}/\bar{x})$ is given by

$$\hat{V}(\hat{R}) = \frac{1}{\bar{x}^2} \frac{1}{k(k-1)} \sum_{s}^{L} \left[\sum_{i}^{k} (y_{si} - \bar{y}_{s\cdot})^2 - 2\hat{R} \sum_{i}^{k} (y_{si} - \bar{y}_{s\cdot})(x_{si} - \bar{x}_{s\cdot}) + \hat{R}^2 \sum_{i}^{k} (x_{si} - \bar{x}_{s\cdot})^2 \right] \qquad \ldots \quad (10.9)$$

and an estimator of the bias in $\hat{R}$ is given by

$$\hat{B}(\hat{R}) = \frac{k\hat{R} - R'}{(k-1)} \qquad \ldots \quad (10.10)$$

where $R' = \frac{1}{k} \sum_{i}^{k} \frac{y_{\cdot i}}{x_{\cdot i}}$, (Murthy and Nanjamma, 1959).

Operationally this technique is convenient because it simplifies the computation of variance in case of complicated designs and at the same time helps having a broad internal check on the results. The efficiency of the variance estimator is, however, impaired due to the reduction in the number of degrees of freedom on which such estimates are based. However, the range of the sub-sample estimates provides a confidence interval for the median of the estimator (which is the same as the mean if the distribution is symmetric) with a confidence coefficient of $1-\left(\frac{1}{2}\right)^{k-1}$ irrespective of the distribution of the estimator. It may be noted that the interpenetrating sub-samples are of value if the survey has to be carried out in successive stages due to the necessity of providing preliminary results. The agreement of the sub-sample estimates is likely to be more convincing to the layman than any statement of sampling and non-sampling errors.

Suppose there are m agencies and n parties of investigators within each agency to conduct the survey. Then 8 or a multiple of mn (say kmn) independent interpenetrating sub-samples may be selected and each party of investigators in each agency may be assigned k sub-samples at random for being surveyed. With this arrangement the total variation of the estimator may be analysed as given below.

source of variation	degrees of freedom
between agencies	$m-1$
between parties	$m(n-1)$
within error	$mn(k-1)$
total	$mnk-1$

This analysis will help in locating the stages of operation where there is much of discrepancy. For instance if the between agency difference turned out to be statistically significant, if would mean that the survey has not been carried out according to the same specifications by one or more of the agencies. Similarly a significant result for the parties would mean that some parties have not functioned according to the specifications.

11. USE OF QUALITY CONTROL TECHNIQUES

The technique of statistical quality control (SQC) may be applied to census and survey work to assess the quality of the work and to improve the out-going quality with suitable corrective action. For this purpose it is desirable to use those SQC techniques which have built-in devices for initiating corrective action. More attention is to be paid to control of errors through SQC techniques than to acceptance plans for finished work. For a particular situation, the best plan is defined as that which ensures the highest out-going quality for a given cost or alternatively the lowest cost for a specified out-going quality. There is considerable scope to apply SQC techniques for control of errors in censuses and surveys because of the large amount of routine repetitive operations involved such as coding, punching etc.

No attempt will be made here to describe all the SQC techniques which may be applied to control errors in surveys. Instead, one procedure is described which is indicative of such applications. Suppose k operators are doing a particular routine operation where the out-put can be checked and the permissible error-rate in the finished work is specified. The work of each operator is first completely checked for a suitable length of time. If the error-rate is less than the specified rate, only a sample of this work is verified in the subsequent periods of time. The decision regarding whether to continue verification on a sample basis or to have complete verification is taken separately for each operator on the basis of his cumulated error-rate over the past period. It may be noted that this procedure will help considerably in reducing the cost of verification and at the same time will ensure a specified quality level for the finished work. It may be mentioned that this type of procedure is being used in the United States Bureau of the Census and that this has been found to be helpful in controlling errors in census and survey work.

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DEVELOPMENT OF INDUSTRIAL STATISTICS IN INDIA*

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SUMMARY. The present paper discusses the important landmarks in the development of industrial statistics in India from 1887 to 1960. The developments have been discussed in chronological order to present a historical perspective. The developments can be broadly classified under following periods :

(i) Developments prior to the implementation of the Industrial Statistics Act, 1942 and the Census of Manufacturing Industries Rules, 1945 covering a period from 1877 to 1946.

(ii) Developments during 1946 to 1958 covering the statutory collection under the Industrial Statistics Act, 1942 and the Census of Manufacturing Industries Rules, 1945, and voluntary Sample Surveys of Manufacturing Industries, for the reference years 1949 to 1958.

(iii) Developments after the implementation of the collection of Statistics Act, 1953 and collection of Statistics (Central) Rules, 1959.

Developments under each period have been discussed with reference to basis of collection (statutory or voluntary), design of the survey, periodicity, territorial and subject coverage, unit of investigation, scope of the survey, items of data, schedules and questionnaire used, response, time-lag in publication, organisation and field agency, limitations of data, monthly statistics of industrial production and indices of industrial production.

INTRODUCTION

Industrial statistics were practically non-existent in India before the Industrial Statistics Act, 1942 and the Census of Manufacturing Industries Rules, 1945 came into force. The available information relating to some of the major large-scale industries collected by non-official agencies like associations and chambers of industry, trade and commerce, *ad hoc* bodies like tariff commissions, fiscal commissions, government authorities, research institutions, and private investigators was very meagre and had to be gleaned from occasional reports, gazetteers, monographs and research studies. The information which could thus be obtained in response to certain specific needs and on voluntary basis was not of requisite quality. The statistics were not only inadequate, but their difference from one another in scope, content, methods, periodicity, degree of detail and accuracy was so markedly pronounced that these could not be used for formulation of economic policies and programmes of industrial development.

2. The Department of Commercial Intelligence and Statistics, Calcutta, collected monthly statistics of production of certain selected industries on a voluntary

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*The views expressed in the paper are author's own and have nothing to do with the Directorate of Economics and Statistics, Madhya Pradesh, Bhopal.

basis from the establishments engaged in the following industries;

(1) distilleries and breweries, (2) cotton textile, (3) jute textile, (4) woollen textile, (5) paper, (6) iron and steel, (7) petroleum, (8) kerosene oil, (9) cement, (10) sulphuric acid, (11) sulphate of ammonia, (12) wheat and flour, (13) sugar and (14) matches.

3. Collection of statistics of some of these industries could be traced back to the seventies of the nineteenth century. For example, information relating to distilleries and breweries is available from 1877; cotton textile and jute textile from 1879. Production figures for woollen textile and paper are available from 1884, iron and steel and petroleum from 1890 and kerosene oil from 1900. Data collected relate to number of establishments, nominal capital employed, average number of persons employed, machinery and equipment installed, quantity and value of production and description of production. These figures are scattered in a number of publications issued by the Department of Commercial Intelligence and Statistics. *Statistics of British India*, Volume II (Commercial), *Statistical Abstract of British India* and *Statistical Abstract relating to British India* are some of the publications in which these production figures were published. These series are defective in a number of ways. Firstly, the data collected relate to former British Indian Provinces and certain Indian States only. Secondly, only large-scale industrial establishments were covered and thirdly, for many of the intervening periods no data are available. For example, woollen production figures are not available for the period from 1922 to 1932.

4. Production figures in respect of other industries such as cement, sulphuric acid, sulphate of ammonia, wheat and flour, sugar and matches are available from April 1932 onwards and along with these figures relating to industries described above excepting cotton textile were published regularly in the *Monthly Statistics of the Production of Certain Selected Industries of India*. The data relating to cotton textile industry were published separately in the *Monthly Statistics of Cotton Spinning and Weaving in Indian Mills*. As stated earlier, the collection was on a voluntary basis with the exception of cotton textiles, sugar and matches. Information relating to production in cotton textile establishments was collected on a statutory basis under the Cotton (Statistics) Act, 1926 and for sugar and matches under the Sugar and Matches (Excise Duty) Act of 1934.

5. In the year 1926, the Government of India enacted the Cotton (Statistics) Act which conferred powers on the Director-General of Commercial Intelligence and Statistics, Government of India, Calcutta, in the matter of collection of statistics of production from the cotton textile mills. In 1937 the executive power was transferred to Provincial (State) Governments by the Adaptation of Laws Order, 1937 which empowered the Provincial (State) Governments to collect statistics of production from cotton textile mills located in their respective Provinces (States). Though the executive power in the matter of primary collection was transferred to Provincial (State) Governments, the coordination in the matter of collection, compilation and tabulation was effected by some agency in the Government of India. For some time

this was done by the Director-General of Commercial Intelligence and Statistics, Calcutta and later on the work was transferred to the Directorate of Industrial Statistics, Ministry of Commerce, Government of India. During the War, the office of the Textile Commissioner was established to administer and enforce the Cotton Cloth and Yarn (Control) Order, 1943 and other price control and regulatory measures and the work of coordination of statistics under the Act was transferred from the Directorate of Industrial Statistics to this office in 1954. Such coordination was carried on by the Textile Commissioner till the Act was repealed in 1958.

INDIAN INDUSTRIAL COMMISSION, 1916–18

6. The question of collecting comprehensive industrial statistics was first examined by the Industrial Commission in 1916-18. The Commission examined the entire question of "Commercial and Industrial Intelligence" and made the following observations with regard to industrial statistics :

"Information regarding production and employment has been in the past exceedingly defective. In the case of production, official figures have been confined almost entirely to the main industries, whose representative associations made it their business to collect them. This is a practice that should receive every encouragement and Government should cooperate with such associations helping them in the collection of their figures, where help is necessary, and obtaining their advice regarding the figures of interest to the trade which Government collects itself. Where no suitable associations exist, the collection of statistics of production should be taken up by Government through provincial Departments of Industries, to the extent that may be considered practicable and useful in each case. We recognise the difficulties that exist, and the necessity of leaving details to be worked out by the industrial organisation of the future."

7. No action was taken by Government to implement the recommendations made by the Commission and the associations of industry and trade continued their work of collection of statistics to meet their needs and requirements. In the absence of effective coordination as recommended by the Commission the data collected lacked coherence and consistency so essential for basic statistical series.

INDIAN ECONOMIC ENQUIRY COMMITTEE, 1925

8. In the year 1925 the Government of India appointed another Committee known as the Indian Economic Enquiry Committee under the Chairmanship of Sir M. Visvesvaraiya. The Committee undertook a detailed survey and study of all the available statistical information in the country required for "framing an estimate of the economic conditions of various classes of people," and made important and definite recommendations after detailed examination and review of the then existing series of industrial statistics. The Committee recommended :

"We consider it essential that, in respect of all large-scale industries, the following statistics should be collected through the Department of Industries and published annually: (a) quantity and value of manufactured goods, (b) quantity and value of raw materials used up in production, (c) added values of manufactures, (d) value of fuel or power used, and (e) number of employees."

"It was suggested by a competent witness that the quantity and grades of the outturn might be ascertained and that they should be evaluated by formulae in the statistical bureau. This plan might be adopted if there is any opposition to the demand for values of outturn."

"The Director of Industries should have no difficulty in securing the information. We have been told in some provinces that the Director can obtain it by persuasion, but legislation would remove any possible obstacles."

"Some witnesses have objected to asking for the value of fuel used on the ground that the enquiry might be taken as an attempt to get at the profits. While we are very reluctant to recommend any measures which would savour of such an attempt, we think, following the example of the United Kingdom and the Dominions, that it is necessary to ascertain the value of coal or other fuel in order to arrive at net production."

"In addition to collecting statistics of production every year, we think, a regular census of production of large industries should be taken quinquennially. The census need not be as elaborate as in the United Kingdom, but particulars regarding the industries might be collected in some detail, including the salaries and wages paid to the staff and workmen, separately for each class of operatives, if the owners of the factories have no objection. The capital invested and the value of lands, buildings and machinery less depreciation, may be ascertained for the purpose of being included in an estimate of wealth, if the establishments concerned are not opposed to such a course. Most factories will, we believe, give such information if secrecy is ensured."

"Details of the information to be collected should, we think, be settled by the Statistics Department in consultation with the Industries Department and the manufacturing establishments concerned. We are advised that legal powers will be necessary for the census of production from large-scale industries."[1]

9. These recommendations were not implemented. However, one relieving feature of this period was the enactment of Cotton Industry (Statistics) Act, 1926 (Act No. XX of 1926) which provided legal base for collection on a monthly basis statistical data relating to the quantities in appropriate units of various varieties of cotton piece goods manufactured and quantities of different counts of yarn spun from the cotton textile mills. Though the provisions of this legislation did not meet

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[1] *Report of the Indian Economic Enquiry Committee*, 1925, Vol. I, 26 and 27.

the requirements of a full-fledged census of manufacturing industries, it at least sought to provide some basic data relating to one important industry. To this extent it was an important development. The data collected under the provisions of this Act were published regularly in the *Monthly Statistics of Cotton Spinning and Weaving in Indian Mills.*

10. In the year 1934 the Government of India invited Mr. D. H. Robertson, the then Lecturer in Economics at the University of Cambridge and Professor A. L. Bowley of the London School of Economics to "advise them on the question of obtaining more accurate and detailed statistics" in general and to make recommendations "on the feasibility and practicability of taking an Economic Census with special reference to the Census of Production and Reorganisation of Statistics" in particular. The following three Indian economists (1) Professor P. J. Thomas, Professor of Economics, Madras University, (2) Mr. D. Ghosh, Lecturer in Economics, Bombay University and (3) Mr. C. Fazal, Assisant Secretary to the Punjab Board of Economic Enquiry were associated with them in their enquiries and investigations. They examined all the available statistical information from the standpoint of computing and measuring national income and wealth. They made the following recommendations for taking a Census of Production.

"*Census of production :* The Census of Production would be imposed (as in Great Britain) by a special Act of the Central Legislature, making communication of the facts demanded compulsory. It would be conducted by the Director of Statistics, the Executive arrangements presumably being made through the Department of Industries and Labour. It appears to be necessary to limit its scope so far as English and American methods are followed to the larger establishments and the natural line which suggests itself is that drawn in the Factory Act, viz., the employment of 20 or more persons combined with the use of mechanical power. It would not seem desirable to extend it automatically to these smaller establishments to which for special reasons of no great statistical significance, Provincial Governments have used their powers of extending the Factory Act. But on the one hand there may be *some* classes of small workshop to which the Census could advantageously be extended, while on the other, there are certainly some large non-mechanical establishments, e.g. in building and constructing, brick making and carpet manufacture, which ought to be brought within its scope. So also should the railways and all establishments be brought under the Mines Act."

"The essential facts to be elicited are the aggregate value of the sales and the aggregate cost of materials for each factory. The difference named in Great Britain the value of the "net output" and in the United States the "value added by manufacture," approximately measures the contribution to the national income of the factory, or, when aggregated, of the industry (so far as it is carried on in factories), after allowance has been made for depreciation of plant and change in value of stocks of materials and finished goods. This value is also the sum divisible among employees, employers, owners, and the local and Central Governments."

"Besides this main estimate, details can be obtained of the amounts and values of different commodities produced, and of materials bought, and of the power used. The arrangement of this part of the schedule is the main subject to be discussed with the trade representatives. It is important that the classification of products should agree with those of exports and imports. The number of employees should be stated, divided as salaried and wage-earners, male and female, young and adult with an exact statement of the age-division between the two. It may be best to get these details for one week in each month of the year, so as to obtain an average for the year and an indication of seasonal movement. It should be considered whether *sirdars* should be shown separately. The results of the Census should be tabulated, so as to show for each industry the distribution of firms by numbers employed."

"The Census, at least in its first taking, would be overloaded, if much detail was asked about wage-rates or earnings. But the total wage bill for the year could be required, possibly with some sub-divisions. Where labourers are engaged and paid by a *sirdar*, efforts should be made to determine how much the sirdar keeps. Besides wage paid in cash monthly or at short intervals, there should be included a statement of all annual or other cash bonuses and cash expenditure for workmen, with a statement of advantages obtained by providing houses or land."[2]

11. The recommendations made by Bowley and Robertson Committee (1934) were not acted upon till the year 1942. In the meantime war broke out in Europe. It was at this time that the Government of India both in the centre and in the provinces strongly realised the real necessity of collecting comprehensive and reliable industrial statistics. *Ad hoc* statistics, collected on a voluntary basis were of little practical utility for the purpose of systematic and scientific study and analysis of the economy of the country. Therefore, it was considered necessary to place the work of collection of industrial statistics on a statutory basis by enacting a legislation on the lines of the recommendations by Bowley and Robertson Committee (1934).

INDUSTRIAL STATISTICS ACT, 1942
(1942 – 1956)

12. In the year 1942 the Industrial Statistics Act was passed. It provided for the collection of statistics relating to any of the following matters from establishments registered and licensed under the Factories Act, 1934, namely, (a) "any matter relating to factories" and (b) "any of the following matters so far as they relate to welfare of labour and conditions of labour" : (i) prices of commodities, (ii) attendance, (iii) living conditions, including housing, water supply and sanitation, (iv) indebtedness, (v) rents of dwelling houses, (vi) wages and other earnings, (vii) provident and other funds provided for labour, (viii) benefits and amenities, (ix) hours of work, (x) employment and unemployment, (xi) industrial and labour disputes.

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[2] See Bowley and Robertson (1934), pages 15-17.

13. The Act, *inter alia*, provided penalties for wilful refusal or neglect to submit a return (in response to a notice served by the Statistics Authority under Section 3 of the Act); wilful furnishing of incorrect or false information; refusing to answer or wilfully giving false answer to any question and impeding the right of access to relevant records and documents. Penalties were also provided for improper disclosure of information or returns to any unauthorized person not connected with the collection of statistics under the Act. The Act also conferred powers on the Statistics Authority to call for relevant records and documents and to enter at any reasonable time any premises wherein such records or documents are kept.

14. This was essentially an enabling Act which conferred statutory powers on the Provincial (State) Governments to frame rules for the collection of statistical data of any kind specified in Section 3 of the Act, but in order to have uniformity throughout the country the initiative of making rules under the Act was not left to the Provincial (State) Governments who under the directions of the Government of India adopted model rules on a uniform basis furnished by the respective ministries in the Government of India. However, the rules made by some of the Provincial (State) Governments slightly differed from the model rules in some minor respects. Though the Act was passed in 1942, it took nearly three years to frame the rules. It was only in the year 1945 that the Census of Manufacturing Industries Rules and the forms of return in respect of first 29 industries were gazetted in the Official Gazettes of the various Provincial (State) Governments. With these technical and legal formalities completed, the stage was set for the commencement of the Census.

15. Following the practice in other industrially advanced countries like U.S.A., U.K., Germany, Australia, New Zealand, South Africa, etc., the censuses of manufactures were planned with the following objectives which have been recognised as the proper objectives for Census of this kind conducted in other countries : (a) estimation of the contribution of manufacturing industries as a whole and of each unit to the national income; (b) systematic study of the structure of industry as a whole and of each type of industry and each unit; (c) causal analysis of the various factors influencing industry in the country; and (d) provision of comprehensive factual and systematic basis for the formulation of policy.

16. The first statutory census was conducted for the reference period 1946, and since then the census was conducted annually on uniform pattern simultaneously throughout India till the year 1956, when the Industrial Statistics Act, 1942 was repealed by the Collection of Statistics Act, 1953. No substantial changes with the exception of the following were made in the Scheme of the Census of Manufactures from 1946 to 1956. (i) The forms of return were redrafted in the year 1949 and revised forms were introduced from the Census year 1950; and (ii) the Census of Manufacturing Industries Rules, 1945 were amended in 1948 to remove certain legal flaws and to meet certain practical difficulties experienced in the efficient conduct of the statutory censuses.

17. Only these two major changes were made in the Scheme of the Census of Manufactures as originally initiated in the year, 1946. The Industrial Statistics Act, 1942, was repealed on 10th November, 1956, and the censuses for the years 1957 and 1958 were conducted on a voluntary basis, other things remaining the same.

18. *Organisation and staff.* At the Centre, the Ministry of Commerce and Industry with the Director of Industrial Statistics, was placed in charge of the census. A separate organisation known as Directorate of Industrial Statistics was set up towards the end of 1945, consisting of one Director, two Deputy Directors, two Assistant Directors, four Research Officers and a number of Statistical Assistants. The main function assigned to the Directorate was to co-ordinate the work connected with the Census of Manufactures and to act as adviser to the State Statistics Authorities in technical and legal matters. As a co-ordinating authority the work of compilation, tabulation, analysis and publication of census data on all-India basis was also entrusted to it. Though the Act did not confer any statutory powers on the Director of Industrial Statistics with regard to the actual conduct of census operations, such co-ordination was effected partly through the powers conferred by Section 11 of the Act on the Central Government to issue directions and partly through the nexus established by the integrated and co-ordinated statistical system evolved in the federal set-up.

19. The Directorate functioned as part of the Ministry of Commerce and Industry till 1st July, 1957, when the administrative control of the Directorate was transferred to the Cabinet Secretariat. In May, 1959 the Directorate was integrated with the Central Statistical Organisation, Cabinet Secretariat and is currently functioning as the Industrial Statistics Wing of the Central Statistical Organisation, Department of Statistics, Government of India. The designation of the Director of Industrial Statistics was changed to Joint Director (Industrial Statistics), Central Statistical Organisation, Department of Statistics, Government of India. The office is still located at Calcutta, but there are proposals to shift it to New Delhi for administrative convenience.

20. In the Provinces (States), the Provincial (States) Statistics Authorities were appointed under Section 4 of the Industrial Statistics Act, 1942 by the respective Provincial (State) Governments. Suitable organisations were established to conduct the census, the actual strength of various categories of staff in each Province (State) depending on the number of establishments, geographical dispersion of factories, preponderance of small factories and such other related factors.

21. Dr. B. N. Kaul, the first Director of Industrial Statistics had done some pioneering work in this period. He was primarily responsible for the drafting of the Census of Manufacturing Industries Rules, Directions under Section 11 of the Industrial Statistics Act, 1942 and the forms of returns for all the 63 industries. The Industrial Statistics Act, 1942 being a permissive legislation conferred all statutory powers in

the matter of service of notice, securing returns, scrutiny and examination of the books of accounts, launching of prosecutions in case of recalcitrant eatablishments, etc., on the State Statistics Authority. The Scheme of the Census of Manufactures had, therefore, to be implemented through the co-operation and assistance of State Governments. It required considerable tact, persuasion and tenacity to convince the States of the utility of the statutory collection of basic industrial statistics.

22. *Unit of investigation.* As recommended by Bowley and Robertson (1934) it was decided that an establishment registered under Section 2(j) of the Factories Act, 1934, (employing 20 or more workers and using power) should be the unit of investigation. It was deliberately decided not to cover smaller establishments employing less than 20 in the initial stages, as it was considered that it would make the census unmanageable at the same time without any substantial advantage from the standpoint of response, reliability and quality of data. The new Factories Act, 1948 came into force on 1st April, 1949. The Act did not provide for a category of establishment corresponding to Section 2(j) of the Factories Act, 1934. The new Factories Act, 1948 provided for two categories of establishments defined under Sections 2(m)(i) and 2(m)(ii). The establishments falling under Section 2(m)(i) are those which employ 10 or more workers on any working day during the year and use power, while under Section 2(m)(ii) are those which employ 20 or more workers on any working day during the year without the aid of power. In spite of this change-over the old Section 2(j) unit of investigation was continued to maintain uniformity and comparability of data collected.

23. *Coverage, response and time-lag.* In 1946 the census covered nine major States and two minor States, namely, Bengal (West), Bombay, Madras, Uttar Pradesh, Bihar, East Punjab, Central Provinces and Berar (Madhya Pradesh), Orissa, Assam Delhi and Ajmer-Marwara. In 1958 the census covered thirteen major States, namely, Bombay, Bengal (West), Madras, Andhra Pradesh, Uttar Pradesh, Bihar, Mysore, Madhya Pradesh, Punjab, Orissa, Rajasthan, Assam, Kerala and two Centrally administered territories of Delhi and Himachal Pradesh. In 1946, the number of factories covered was 5,013, while in 1958 the number was 8,068. The response in 1946 was 80 per cent and it reached the highest 94 per cent in 1954. The last year of the Census of Manufactures in 1958, the response was 82 per cent. The low response was mainly due to the voluntary basis of collection.

24. There is a considerable time-lag in the publication of the results of the census which are usually not available several years after the census. The time-lag on an average has been between 2 to 3 years. From 1949 onwards the summaries are published more promptly in the *Monthly Production of Selected Industries of India*, a monthly publication issued by the Central Statistical Organisation (Industrial Statistics Wing), Cabinet Secretariat, Government of India.

25. *Classification of industries and establishments.* All the factory establishments were classified under 63 industry groups (known as the C.M.I. classification)

on the basis of information then available regarding the structure of industries. The census in the first instance was extended to the following first 29 industries and in spite of the completion of all legal and technical formalities the census was never extended to the remaining 34 industries. The census remained confined to the following 29 industries till 1958, when it was replaced by the Annual Survey of Industries under the Collection of Statistics Act, 1953 :

(1) Wheat flour, (2) rice milling, (3) biscuit making (including bakeries and confectioneries), (4) fruit and vegetable processing, (5) sugar, (6) distilleries and breweries (including power alcohol manufacturing), (7) starch, (8) vegetable oils—oilseed crushing and extraction and processing of vegetable oils, (9) paints and varnishes (10) soap, (11) tanning, (12) cement, (13) glass and glassware, (14) ceramics, (15) plywood and tea chests, (16) paper and paper board (including straw-board), (17) matches, (18) cotton textiles—spinning and weaving, (19) woollen textiles, (20) jute textiles, (21) chemicals including drugs and pharmaceuticals, (22) aluminium, copper and brass—all processes from ore smelting to manufacture of final products ready for sale, (23) iron and steel smelting (including blast furnace operations), rolling and re-rolling, (24) bicycles, (25) sewing machines, (26) producer gas plants, (27) electric lamps, (28) electric fans, (29) general engineering and electrical engineering (excluding generation and transformation of electrical energy).

26. The defence establishments owned, managed and controlled by the Ministry of Defence, irrespective of the industry to which they belonged and the establishments and workshops attached to the training institutions, colleges, technical institutions, etc., were excluded from the census. The remaining establishments, irrespective of ownership, management and control were covered. From 1952 onwards the producer gas plant industry was excluded, as it went out of existence with the progressive liberalisation of controls imposed on the consumption of petrol during war-time.

27. All the factory establishments falling under any of the 29 industries were classified under one of the industries. In case of mixed establishments engaged in the manufacture of products falling under more than one industry, such establishments were classified on the basis of principal products and their value. In other words, each establishment was classified under one industry group and particulars relating to the manufacturing activities carried on in the establishment were collected in the return relating to the industry under which the establishment was classified. In an institutional approach implicit in the statistical unit of establishment, all the activities carried on by the establishment are to be netted in one single return. Factories which remained closed throughout the year for whatever reasons were, however, covered, if these were registered under the Factories Act and were borne on the registers of Factory Inspectorate.

28. *The form of return.* The forms of return used in the census of manufactures have been designed on a uniform pattern for all industries. They consist of

following eight tables, the first four tables being identical for all industries. The next two Tables E and F which are designed to collect data relating to the materials consumed and products and by-products manufactured and work done naturally differ from industry to industry. The last Table G is, however, common to all industries.

(1) Table A : Name and address of the factory. (2) Table B(1) : Duration of working during calendar year. (3) Table B(2) : Capital structure as on the 31st December of the year or on the date on which books of accounts were last closed during the year of return. (4) Table C : Labour employed, wages paid and man-hours worked during the calendar year. (5) Table D : Fuels, electricity, lubricating materials and water actually consumed during the calendar year. (6) Table E : Basic or principal materials, chemicals and packing materials actually consumed during the calendar year and value of work given out to other factories or concerns. (7) Table F : Products and by-products manufactured, value of repair work done and value of work done for other customers or concerns on materials supplied by them. (8) Table G : Power equipment employed, cost of energy and fuel consumption during the calendar year.[3]

29. These forms of return were first drafted in the year 1945 and were used for securing returns relating to the years 1944 and 1945 on a voluntary basis and for 1946 to 1949 on a statutory basis. In the year 1949 these forms were revised and redrafted in the light of experience gained in the conduct of two voluntary and three statutory censuses and the difficulties experienced by the State Statistics Authorities and factory owners. The revised forms were ratified in the year 1949 by notifying these in the Official Gazettes of State Governments and were introduced from the census year 1950. The revised forms differed from the original forms in certain respects. The most marked difference between these two sets of forms was that the forms which were in use prior to 1950 contained detailed and exhaustive instructions for filling up the various tables given in the form, while these were omitted from the body of revised forms. The other important improvements made in the form of return were as under :(i) Provision was made to collect particulars relating to the number of days on which *only* maintenance work was carried on. (ii) Provision was made to collect separate particulars relating to the value of land on which the factory is situated and the value of factory buildings instead of one consolidated value for both items under the old forms. (iii) Provision was made to collect separate particulars on various components of working capital instead of the one consolidated figure (plus or minus) in the old forms. (iv) Classification of labour employed was revised so as to conform to the classification under the Factories Act, 1948. Provision was made to secure two sets of figures, namely, (a) employees within the Factories Act, 1948, and, (b) employees not within the Factories Act, 1948. (v) Provision was made to secure one consolidated figure of money value of any privileges, benefits, etc., instead of separate figures for each category of employees (men, women,

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[3] In Bombay State only.

children, persons other than workers). (vi) Detailed classification of workers employed through contractors into men, women, children was abandoned and in its place provision was made to collect one consolidated figure for all categories of workers. (vii) Detailed distribution by quantity and value of each item of material purchased and consumed by source of supply (indigenous, imported and not known, whether indigenous or imported) was abandoned and in its place provision was made to collect quantity and value figures of each material consumed, irrespective of source of supply. (viii) Provision was made to collect data relating to following items under input (Table E) table. (a) Value of semi-finished products in stock or in process *at the beginning* of the year. (b) Value of finished products or parts of products, if any, used during the year for further manufacture, but which were shown as products for sale under out-put for the previous year. (ix) Provision was made to collect data relating to the following items under output (Table F) table. (a) Value of semi-finished products in stocks or in process at the close of the year. (b) Value of repair work done (in case of some of the industries such as General Engineering and Electrical Engineering (C.M.I. 29), Automobiles and coach building (C.M.I. 56), Ship building and ship repairs (C.M.I. 57), Railway factories (C.M.I. 58) and Aircraft assembling, repairs and servicing (C.M.I. 60). (x) The lists of basic materials, chemicals and packing materials consumed and products and by-products manufactured were revised and made exhaustive and up-to-date. (xi) The following items which were provided in the old forms were deleted from the revised forms of return. (a) Paid-up capital of the establishment. (b) Paid-up capital of the firm. (c) Names of other undertakings owned by the establishment. (d) Year of establishment of the factory or the year of acquisition. (e) Duration of working — seasonal or perennial.

30. In the year 1947 forms of return for the remaining 34 industries were also drafted in consultation with the representatives of the industries concerned. These were also revised when the forms of return relating to 29 industries were revised in 1949, but for some administrative and financial difficulties the Census was never extended to the remaining 34 industries though all the legal formalities were completed.

SAMPLE SURVEYS OF MANUFACTURING INDUSTRIES (1949—1958)

31. In August, 1949 the Government of India by its Resolution No. 15(33)-P/49 appointed the National Income Committee with Professor P. C. Mahalanobis, Professor D. R. Gadgil and Dr. V. K. R. V. Rao, as members. The terms of reference of the Committee were as under :

"The terms of reference of the Committee are to prepare a report on the National Income and related estimates, to suggest measures for improving the quality of the available data and for the collection of further essential statistics and to recommend ways and means of promoting research in the field of national income. The

Committee will also guide the National Income Unit of the Government of India to compile authoritative estimates of the national income."[4]

32. The Committee first addressed itself to the task of examining the available statistical series in India and their adequacy for the purpose of estimating national income of India. The Committee found that most of the available statistical material was inadequate, grossly inexact, incomplete and misleading. There were large gaps in the material and with these gaps the Committee could not proceed to compute the national income of India. The field of industrial statistics was also subjected to closer examination and scrutiny. The Committee found that the coverage of the Indian Census of Manufactures was inadequate in many respects. The series suffered from following defects :

(i) The Annual Census of Manufactures conducted under the Industrial Statistics Act, 1942 and the Rules framed thereunder, covered only the first 29 industries out of the 63 industrial groups into which all establishments registered and licensed under the Factories Act were classified for the purpose of the Census. (ii) The Annual Census of Manufactures covered establishments registered and licensed under Section 2(j) of the Factories Act, 1934, i.e. employing 20 or more workers with the aid of power. (iii) The Annual Census of Manufactures did not extend to many of the Part B and C States such as Madhya Bharat, Jammu and Kashmir, Hyderabad, Mysore, Bhopal, Bilaspur, Manipur, Tripura, etc.

33. An idea regarding under-coverage can be had from the following :

"Further, although by that time a large number of establishments should have been considered as factories according to the 1948 Factories Act, the Census had been working on the basis of the older definition of factories according to the 1934 Act. The difference was indeed large. Under the 1948 Act there were about 28,000 factories in the country in 1949 but according to the older definition, there were only about 17,000 factories and the Census was covering between 6,500 and 7,000 factories only."[5]

34. The Committee considered it essential to have fairly reliable estimates of the countribution of the manufacturing industries to the national income as early as possible. The Committee, therefore, recommended to the Government of India to conduct a rapid sample survey of all factory establishments in India so that the contribution of the manufacturing industries to the national income could be estimated with reasonable degree of accuracy. The Government of India agreed to this proposal and decided that Sample Survey of Manufacturing Industries for the reference periods

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[4] *First Report of the National Income Committee*, April, 1951. The Department of Economic Affairs, Ministry of Finance, Government of India, 1951, Chapter 1, page 1.

[5] *Report on the Sample Survey of Manufacturing Industries*, 1949 and 1950 (NSS Report, 11), Cabinet Secretariat, Government of India, 1958, page iii.

1949 and 1950 should be carried out by the Directorate of Industrial Statistics with the technical assisatance of Indian Statistical Institute, Calcutta. A separate unit was set up in the Directorate of Industrial Statistics, Simla, to conduct the survey. It consisted of (i) an Officer-on-Special Duty, (ii) six Regional Research Officers, and (iii) thirtytwo Investigators. The Director of Industrial Statistics was placed in over-all charge of the survey for administrative as well as field purposes. The field work started in the middle of January, 1951. The first phase of the field operations (first part of the sample) was completed by the third week of March and the second part was completed by the middle of June, 1951. Shri P. N. Nayar was appointed as Officer-on-Special Duty for conducting the Sample Survey of Manufacturing Industries for the years 1949 and 1950, the first of its kind in India. Shri P. N. Nayar was primarily responsible for the design of the survey and field operations.

35. The Sample Survey covered all the 63 industry groups excepting those under the control and management of Ministries of Defence and Railways. Establishments employing 20 or more workers and using power were covered. The survey could not be extended to establishments registered and licensed under Sections 2 (m) (i) and 2(m)(ii) of the Factories Act, 1948, i.e. employing 10 or more workers and using power and 20 or more workers and not using power, as the lists of establishments falling under these two categories were not available at the time of design of the survey. The survey was, therefore, limited to Section 2(j) Factories, i.e. employing 20 or more workers and using power. In subsequent sample surveys, however, the scope was extended to cover all establishments registered and licensed under Sections 2(m) (i) and (m) (ii) of the Factories Act, 1948. In terms of geographical coverage the survey was extended to the whole of India excluding Jammu and Kashmir and Andaman and Nicobar islands.

36. The technical work such as design of the survey, selection of sampling units, drafting of schedules and instructions, examination and scrutiny of schedules, etc., relating to the first round of the sample survey for the reference years, 1949 and 1950 was done at the Directorate of Industrial Statistics, while tabulation, analysis of data, etc., were carried out by the Indian Statistical Institute, Calcutta. From the second round of the sample survey from 1951 onwards all the technical work relating to the survey was transferred to the Indian Statistical Institute, Calcutta. In the first round of the sample survey data were collected on the same items and with similar details as in the Censuses of Manufactures. The concepts, terms and definitions used were practically the same as in the Censuses of Manufactures. In subsequent rounds the scope of the enquiry was enlarged so as to collect data on a wide variety of subjects relating to various aspects of the manufacturing industry. Although the concepts, terms and definitions used in the sample surveys conformed broadly to the concepts, terms and definitions used in the Censuses of Manufactures, in the subsequent rounds of the sample surveys, certain minor changes were made in the concepts and definitions. The 'value added by manufacture' as given by the Sample Surveys of Manufactures differs from the 'Census value added by manufacture' as given by the Censuses of Manufactures in that the former is gross of depreciation, while the latter is net of depreciation.

37. From the survey for the reference year, 1954, the scope of the sample surveys was modified to cover scheduled undertakings (establishments, plants or technical units) licensed under the Industries (Development and Regulation) Act, 1951. This was done on an exploratory basis. In 1955 it was extended to cover all scheduled undertakings (establishments, plants or technical units, excepting coal) and in 1956 and 1957, it was further extended to cover all classifications including coal. Data relating to these scheduled undertakings are proposed to be processed separately. National Sample Survey Report No. 62 (Draft) gives results of the Scheduled Undertakings sector for 1957.

38. The preliminary estimates of the contribution of manufacturing industries based on the first phase of the enquiry were furnished to the National Income Committee by April, 1951 and final estimates were made available by the end of 1951. Final report containing detailed analysis and tables was completed by February, 1952, but was not published till 1958.

39. In 1952 it was decided to continue these sample surveys on a regular basis. As the Directorate of Industrial Statistics was conducting the annual Censuses of Manufactures under the Industrial Statistics Act, 1942 through the State Statistics Authorities, it was decided to entrust the work connected with the sample surveys to the Directorate of National Sample Survey, Cabinet Secretariat, Government of India and subsequent sample surveys from 1951 onwards have been carried out by the Directorate of National Sample Survey.

40. From 1951 the scope of the sample surveys was extended to cover all factory establishments registered and licensed under Sections 2(m) (i) and 2(m)(ii) of the Factories Act, 1948 excepting those under the Ministries of Defence and Railways. The geographical coverage remained the same as in the previous surveys for the years 1949 and 1950 till 1953, when the survey was extended for the first time to the State of Jammu and Kashmir. As the experience gathered, many technical improvements in the design of the survey, layout of the schedule and analysis of data were made. One special feature of these surveys which needs to be commented upon is that during each round some additional information relating to some aspect of industry was collected in addition to the minimum programme. The following additional information was collected in the sample surveys conducted from 1951 to 1958.

41. The additional information required to meet the specific needs arising out of the planning and development, estimation of national income, formulation of appropriate industrial policies and programmes, etc., was collected without any additional costs and legal formalities which are attendant in a statutory census like Census of Manufactures. The additional information was utilised extensively for the formulation of the Second Five Year Plan, in addition to a wide variety of other uses to which it was put.

reference period	additional data collected
1951	1. estimated requirements under expansion programme during 1952-56
1952	1. employment : change in volume
	2. housing provision for the employees
1953	1. employment : change in volume
	2. housing provision for the employees
	3. gross value of sales
	4. costs of distribution
1954	1. present age and expected service life of buildings, plant and machinery
	2. power equipment installed-prime movers and electric motors
	3. transactions in fixed assets during the accounting year
	4. expenditure on repairs and maintenance (Materials, labour costs, service charges etc.)
	5. employment : change in volume
	6. inward freight
	7. particulars of intermediate products
	8. payments made on account of other services such as printing ; advertising ; warehousing ; insurance ; purchase agency ; audit ; accounts, and bank ; managing agency and other services.
	9. trend of production and possibilities under existing fixed capital equipment
	10. stocks, supply and utilisation of selected articles
1955	1. employment : change in volume
	2. group benefits
	3. industrial benefits
	4. intermediate products (fuels) produced
	5. intermediate products other than fuels produced
	6. payments made on account of other services such as printing ; advertising, warehousing ; insurance ; purchase agency ; audit, accounts and bank ; managing agency and other services
	7. trend of production and possibilities under existing fixed capital equipment
1956	1. programme of expansion during 1956-61
	2. same as item 6 in 1955
1957	1. programme of expansion during 1956-61
	2. same as item 6 in 1955
1958	1. selected products manufactured during the calendar years, 1957 and 1958
	2. same as item 6 in 1955
	3. distributive costs during the calendar years, 1957 and 1958
	4. production possibilities under existing fixed capital equipment during the calendar years, 1957 and 1958

42. The results of the sample surveys for the reference periods from 1949 to 1955 have so far been published and draft reports relating to the subsequent reference years have been prepared and submitted to the Government of India for approval. This is the only series which provides the basic data relating to the entire sector known as factory production.

43. An account of this period would not be complete without a mention of the observations of the National Income Committee with regard to the sample surveys of manufacturing industries.

44. The Committee which utilised the data collected in the sample surveys of manufacturing industries for the purpose of estimating the contribution of manufacturing industries to national income found some grave discrepancies in the two sets of estimates, one given by the Census of Manufactures and the other by sample survey of manufactures. It appears that the Committee became slightly sceptical about the reliability of estimates thrown up by sample surveys of manufactures. The Committee, therefore, expressed the following views in their Final Report :

"While there should be no objection to sample enquiries filling gaps left by the annual census we would be opposed to any move that negatives the good beginning made by the DIS (Director of Industrial Statistics) by initiating the annual census of manufacturing industries. We say this because instead of trying to make good its deficiencies in regional and subject coverage, there has been apparent, in recent years, a tendency to replace the census itself by means of a sample survey. If an annual census of manufacturing industries is not manageable, it would be made manageable by spreading it over a number of years. But it does not seem advisable to replace this systematic record by means of sample estimates. There are various ways by which the annual census may be distributed over a number of years. Firstly, there is the method of partial annual census with full coverage, in three or five years, which we have mentioned in connection with the crop area statistics. In relation to the census of manufacturing industries, the method might be modified in various ways. Thus the units to be covered in any year, instead of being drawn from all groups of industries might be confined, if that appears more convenient, to only a few groups of related industries which (groups) in the particular year might be fully covered. Or preferably, only the larger units in the more important industries might be covered every year while the remainder might be covered by a partial census spread over three or five years. There are more variations and the one which is most suitable to administration might be adopted. We feel, however, that the basis of this collection should be a systematic census and not a random sample survey."[6]

45. However, the Chairman, Professor P. C. Mahalanobis, reserved his opinion on the view expressed by the Committee. Presumably, he did not concur with the views of other members of the Committee on this score.

46. Following the repeal of the Industrial Statistics Act, 1942, some of the State Governments like Bombay (Maharashtra), Kerala, etc., launched Sample Surveys of Manufacturing Industries in their respective States on the same lines as National Sample Surveys of Manufacturing Industries, the only difference being that in these surveys the item coverage was restricted to the minimum programme unlike the NSS Sample Surveys of Manufacturing Industries. The results of these surveys have not so far been released.

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[6] National Income Committee, Final Report, 1954, pages 67 and 68, para 2.138.

COLLECTION OF STATISTICS ACT, 1953

47. In 1953 the Parliament passed the Collection of Statistics Act, (No. XXXII of 1953), but it was not brought into force till the 10th November, 1956, when a notification bringing it into force at once was issued. The reasons for keeping the enactment in abeyance from 1953 to 1956 appear to be that the statistical agencies and organisations in the Government of India were contemplating enacting a new legislation provisionally christened as Census and Statistics Act repealing the Census Act, 1948, the Collection of Statistics Act, 1953 and Cotton Industry (Statistics) Act 1926. The Act provided for the collection of all kinds of statistics on a wide variety of subjects from Census of Population to local bodies statistics. It was a comprehensive draft seeking to centralise statutory collection of all kinds of statistics in one authority. The various agencies and organisations which were likely to be affected by this draft legislation did not agree with the centralisation of collection contemplated in the draft of the Census and Statistics Act and it seems that the idea of having one single legislation for the collection of all kinds of statistics had to be dropped.

48. The Government of India in the Ministry of Commerce and Industry, therefore, issued a notification under sub-section (3) of Section 1 bringing the Collection of Statistics Act into force on 10th November, 1956. On this date the Industrial Statistics Act, 1942 stood repealed. The promulgation of the new Act has entirely changed the basis of industrial censuses in India. The Collection of Statistics Act, 1953 is radically different in structure, composition and legalistic aspects from the Industrial Statistics Act, 1942. The latter, being a permissive legislation, conferred all powers on the State Governments and State Statistics Authorities, while the Collection of Statistics Act, 1953 confers concurrent powers on both Central and State Governments for collection of statistics relating to any of the matters specified in Section 3 of the Act with overriding powers vesting in the Central Government. These concurrent powers do not give unfettered freedom to State Governments to collect statistics in respect of any subject, because the State Governments have no exclusive powers to collect data even in respect of subject mentioned in list II — State list, but they derive the power from Entry 45 in list III — Concurrent list, i.e. both the State and Central Governments have concurrent powers in the matter of collection of data in respect of subjects mentioned in lists II and III of the Seventh Schedule of the Indian Constitution. Their powers have been circumscribed by the proviso (a) to Section 3 which states that State Governments are not authorised to collect statistics "relating to any matters falling under any of the entries specified in list I in the Seventh Schedule to Constitution." Provisos (b) and (c) to Section 3 of the Act have further circumscribed the powers of the States to collect data relating to any of the matters specified in Section 3 of the Act.

49. The Collection of Statistics Act, 1953 is a comprehensive legislation, the various provisions of which have been designed to collect data on various subjects listed in Section 3 of the Act from establishments, factories, workshops, mines, quarries, enterprises, companies, co-operative societies, firms, public

utilities, commercial undertakings, banking and insurance companies, financial corporations, shipping and navigation concerns, brokers dealing in shares, stocks and securities and commodities, advertising consultants, light railways, transport undertakings, plantations (rubber, tea, coffee or cinchona), forwarding and clearing agents and any other concern which is declared as commercial concern by Central Government by notification in the Official Gazette. While the Industrial Statistics Act, 1942 authorised collection of statistics from factories only, the Collection of Statistics Act, 1953 authorises collection from a wider field covering almost all economic activities. In terms of International Standard Industrial Classification the Act empowers the appropriate authorities to collect data from Major Group—"01 Agriculture and Livestock production—Plantation" in Division 0 to "Major Group—84, Personal Services" in Division 8. Statistics can be collected relating to any of the following matters, namely : (a) any matter relating to any industry or class of industries; (b) any matter relating to any commercial or industrial concern or class of commercial or industrial concerns, and in particular, any matter relating to factories; (c) any of the following matters so far as they relate to welfare of labour and conditions of labour, namely; (i) prices of commodities; (ii) attendance; (iii) living conditions including housing, water supply and sanitation, (iv) indebtedness, (v) rent of dwelling houses, (vi) wages and other earnings, (vii) provident and other funds provided for labour, (viii) benefits and amenities provided for labour, (ix) hours of work, (x) employment and unemployment, (xi) industrial and labour disputes, (xii) labour turnover, and, (xiii) trade unions.

50. The Act, *inter alia*, provides for penalties for non-compliance with the various provisions of the Act, and for improper disclosure of information to any unauthorised persons. The Act confers powers to call for information or returns and right of access to records or documents. These provisions are similar to those provided in the Industrial Statistics Act, 1942.

51. Though the Act was brought into force on 10th Novermber, 1950, it took nearly three years to frame the Rules. The Collection of Statistics (Central) Rules, 1959 were finally notified in the Government of India Gazette on 2nd January, 1960. The rules framed are broadly patterned on the lines of the Census of Manufacturing Industries Rules, 1945 framed by the various State Governments unders Section 12 of the Industrial Statistics Act, 1942 with the exception of one provision which is a definite improvement over the Census of Manufacturing Industries Rules, 1945. The particulars and items on which data can be statutorily demanded by the Statistics Authority have been stated in sufficient details in Rule 4, thus dispensing with the forms of returns, questionnairs or schedules forming a part of the Rules as was the case with Census of Manufacturing Industries Rules, 1945. This innovation has introduced flexibility in the matter of collection of data as the schedules can be modified suitably at any stage within the provisions of Rule 4 of the Collection of Statistics (Central) Rules, 1959. Under the Census of Manufacturing Industries Rules, 1945, the forms of return which formed a part of the Rules as Schedule II could not be modified without

going through the legal process of issuing draft amendments and final amendments to the Rules. Indication of the particulars on which data are required in the notice to be served under the Rule 3 under the Collection of Statistics Act, 1953 is sufficient compliance with the Collection of Statistics (Central) Rules. The definitions of various concepts and terms used and the degree of detail with which data on various 'particulars' are required become matters of drafting the forms of return and instructions. This gives ample scope for manoeuvrability and flexibility in the matter of collection of details under various heads so long as collection remains confined within the framework of Rule 4.

52. The Government of India in the Cabinet Secretariat (Notification No. SO 462, dated the 18th February, 1960) have directed that statistics shall be collected relating to all of the following matters: (i) commercial concerns as defined in clause (b) (ix) of Section 2 of the Collection of Statistics Act, 1953, (ii) industrial concerns, and, (iii) Factories.

53. By the same notification the Government of India have appointed the Chief Director, National Sample Survey, Cabinet Secretariat as Statistics Authority under Section 4 of the Act.

ANNUAL SURVEY OF INDUSTRIES, 1959

54. With the calendar year, 1959 the Government of India in the Cabinet Secretariat launched the first statutory survey of industries under the Collection of Statistics Act, 1953 (32 of 1953) and the Collection of Statistics (Central) Rules, 1959. With the launching of this survey the Censuses of Manufactures so far conducted under the Industrial Statistics Act, 1942 and the Census of Manufacturing Industries Rules, 1945 and the Sample Surveys of Manufacturing Industries were terminated. The statutory survey marked off a new phase in the collection of basic industrial statistics in India. In what follows an attempt has been made to examine the special features of the Annual Surveys of Industries for 1959 and 1960 and how the scheme of the survey differs from the earlier scheme of the Census of Manufactures.

55. *Design, scope and coverage of the survey.* An integrated scheme designed as 'Annual Survey of Industries, 1959' was formulated for the collection of basic industrial statistics by conducting censuses and sample surveys on a statutory basis. The scheme envisaged conducting of : (i) Census in respect of all factories employing on any day 50 or more workers with the aid of power and 100 or more workers without the aid of power, and, (ii) sample survey in respect of the factories employing 10 to 49 workers with the aid of power and 20 to 99 workers without the aid of power and industrial concerns, happened to be selected in the probability sample for the survey year under consideration.

56. The Annual Survey of Industries replaced the following surveys conducted till the calendar year, 1958. (i) The Census of Manufactures conducted under the Industrial Statistics Act, 1942. This Census was carried on annually from 1944

to 1958 on a statutory basis with the exception of first two and last two years, when it was conducted on a voluntary basis. (ii) The Sample Surveys of Manufacturing Industries initiated in the year, 1951 in the then Directorate of Industrial Statistics on a voluntary basis. Since 1951 this survey was being conducted annually by the Directorate of National Sample Survey, Cabinet Secretariat, Government of India.

57. The Annual Survey of Industries, 1959 covered all factories registered and licensed under the Factories Act, 1948 and industrial concerns as defined under clause (d) of Section 2 of the Act with the exception of the following: (1) iron ore mining; (2) metal mining except iron ore mining; (3) stone quarrying, clay and sand pits; (4) salt mining and quarrying; (5) chemical and fertiliser mineral mining; (6) non-metallic mining and quarrying not elsewhere classified.

58. As in the Censuses and Sample Surveys of Manufacturing Industries, the establishments owned, managed or controlled by the Ministries of Defence and Railways and training workshops attached to the technical institutions were excluded from the survey. The geographical coverage of the survey was determined by the provisions of the Collection of Statistics Act, 1953. According to sub-section (2) of Section 1 of the Collection of Statistics Act, 1953, the Act extends to the whole of India except the State of Jammu and Kashmir. However, the factories in Jammu and Kashmir were covered on a voluntary basis.

59. *Form of return.* One single form of return consisting of Parts I and II was designed. The two parts together were prescribed for factories employing *on any day* 50 or more workers with the aid of power and 100 or more workers without the aid of power and industrial concerns (mines and quarries) happened to be selected in the probability sample. Part I was prescribed for factories employing 10 to 49 workers with the aid of power and 20 to 99 workers without the aid of power happened to be selected in the probability sample. Part II contained certain extension blocks for specific industries which were indicated in the Industrial Classification adopted for the survey. The following extension blocks were to be filled for such industries:

Block (22): Consumption of raw materials other than fuels, electricity, lubricants, etc., (excluding intermediate products) during the year.

Block (23): Products and by-products (excluding intermediate products) made for sale during the year.

Block (28): Stocks of fuels, raw materials and products at the end of the year.

60. A classified list of materials and products in respect of which information relating to consumption, production and stocks was to be reported was given in Appendix V to the Memorandum on Concepts, Definitions and Procedures.

61. The following new information which was not collected at any time either in the Censuses or Sample Surveys of Manufacturing Industries was collected for the first time under the Annual Survey of Industries, 1959: (1) equipment other than

power equipment installed; (2) categorisation of workers into skilled, semi-skilled and unskilled for factories in category (i) and industrial concerns in category (ii); (3) installed capacity of production ; (4) sales effected during the year by type of consumer ; (5) management and labour relations ; (6) particulars of training facilities given by the factory ; (7) particulars relating to industrial research.

62. Memorandum containing the Collection of Statistics Act, 1953, the Collection of Statistics (Central) Rules, 1959, definitions, concepts, instructions, procedures, industrial classifications and product classification was printed separately and it formed a part of the form of return and notice served under Section 5 of the Collection of Statistics Act, 1953.

ANNUAL SURVEY OF INDUSTRIES, 1960

63. In the conduct of the Annual Survey of Industries, 1959, certain difficulties were experienced both by the reporting as well as by collecting agencies. It was felt that the form of return prescribed was unwieldy and needed rationalisation to avoid duplication and to eliminate such items of information as were not necessary to be repeated every year. A review was, therefore, made of the concepts, definitions, and procedures adopted; subjects and items on which information was sought, and the need for types of data required both by Government and industry for industrial planning and development. The Governmental and private organisations concerned were consulted to ascertain their views in the matter. As a result of this review, discussions and consultations the following important changes were effected in the Annual Survey of Industries :

(i) A single form of return without any separate Parts as was the case in the 1959 forms of return was adopted for both Census and Sample Surveys. (ii) One set of concepts and definitions were adopted for all types of establishments. (iii) The number of extension blocks to be filled for certain specified industries was reduced from 3 to 1. (iv) The following items were deleted from the form of return : (a) distributive costs during the year ; (b) equipment other than power equipment ; (c) present age and further expected life of buildings, plant and machinery ; (d) categorisation of workers into skilled, semi-skilled and unskilled ; (e) incidental expenditure ; (f) production of fuels, electricity, etc., as intermediate products ; (g) industrial servicing ; (h) management and industrial relations; (i) sales effected during the year; (j) particulars of training facilities given by the factory ; (k) particulars relating to industrial research. (v) The size of the form of return was considerably reduced as a result of adoption of one single form for all establishments instead of two Parts as in 1959 form, by rearrangement of various Blocks, by combination and elimination of certain items and by removing Summary Blocks. (vi) The anomalies noticed in the various concepts and definitions adopted and coding were rectified.

64. With the exception of the above changes no changes were effected either in the design of the survey, or in the minimum list of items recommended by the Statistical Commission, United Nations in their publication *International Recommendations*

in Basic Industrial Statistics. The form of return was simplified without at the same time sacrificing the essential details and particulars collected in an Annual Survey of Industries.

MONTHLY STATISTICS OF PRODUCTION

65. Apart from the annual Censuses and Sample Surveys of Manufacturing Industries described above, statistics of industrial production are also collected on a monthly basis by various organisations and authorities which have been charged with the regulation or development of some aspects of the industries concerned. The following are some of the principal organisations and agencies that collect monthly statistics of production.

organisation	industries
1. Coal Controller, Calcutta	coal
2. Chief Inspector of Mines, Dhanbad and Indian Bureau of Mines, Nagpur	iron ore
3. Vegetable Oil Products Controller, New Delhi	(1) sugar, and (2) vegetable oil products (vanaspati)
4. Indian Coffee Board, Bangalore	coffee
5. Tea Board, Calcutta, United Planters' Association, Southern India, Connor and Indian Tea Association, Calcutta	tea
6. Salt Commissioner, Jaipur	salt
7. Textile Commissioner, Bombay	cotton, wool and rayon calico looms, complete ring, spinning, frames and carding engines.
8. Indian Central Jute Committee, Calcutta	jute
9. Iron and Steel Controller, Calcutta	iron and steel
10. Geological Survey of India, Calcutta and Indian Bureau of Mines, Nagpur	gold
11. Central Water and Power Commission (Power Wing), Simla	electricity
12. Development Wing, Ministry of Commerce and Industry, New Delhi	the remaining industries

66. With the exception of coal, sugar, vegetable oil (Vanaspati), tea, salt, cotton, woollen and rayon textiles and iron and steel, where the collecting organisations have statutory powers to call for returns, the statistics relating to remaining industries are collected on a voluntary basis. As the collection in case of most of the industries is on a voluntary basis, the utility of many of these production series is diminished because, (1) the coverage and scope have been limited to large units in the industries; (2) the percentage of response is not uniform from month to month; (3) the percentage of response in certain cases is very low; (4) the quality of data is not uniform and in some cases very poor; and, (5) the estimation of production figures in cases of defaulting units introduces arbitrary judgements.

67. Even where the data are collected on a statutory basis, the series suffer from some of the defects noted above in the absence of adequate organisation and staff to secure compliance with the statutory provisions and launch prosecutions in case of defaults.

68. With the exception of three industries, viz. (i) woollen manfuactures, (ii) matches, and (iii) electricity generated, where the figures relate to Jammu and Kashmir also, the territorial coverage of the remaining series is limited to Indian Union excluding Jammu and Kashmir.

Statistics collected relate to : (i) installed capacity in case of all industries excepting coal, iron ore, coffee, tea, salt and gold ; (ii) volume of production in one or more than one unit, wherever it is conventional and feasible ; (iii) stocks of finished products at factories at the end of the month.

69. In addition to these production statistics, information relating to the consumption of basic materials, employment, wages, disputes, hours of work, accidents, machinery installed, exports and imports, etc., are also collected on a monthly basis and such additional information is either published by the collecting agency or organisation in its monthly or annual publication or issued in a mimeograph form for limited circulation.

70. All these production statistics are regularly published in the *Monthly Statistics of the Production of Selected Industries of India*, issued by the Central Statistical Organization (Industrial Statistics Wing), Cabinet Secretariat, Government of India, Calcutta. The distribution of statistics is given over industries and States. The scope of series is continuously enlarged by including more industries. Since January 1950, seventy new industries have been covered. Simultaneously, the scope of distribution by States is also enlarged. This publication also contains the index numbers of industrial production.

71. As stated earlier, some of the collecting agencies published their own monthlies incorporating therein the statistics collected by them in respect of the sphere controlled or regulated by them. The following are some of the important monthlies issued by the collecting agencies :

(1) *Indian Cotton Textile Industry*, Textile Commissioner, Ministry of Commerce and Industry, Government of India. (2) *Jute Bulletin*, Indian Central Jute Committee, Calcutta. (3) *Monthly Coal Bulletin*, Chief Inspector of Mines, Ministry of Labour and Employment, Dhanbad.

72. These monthly publications give such additional information which may be of interest to the persons, organisations and agencies connected with the industry concerned.

73. The monthly statistical bulletin *Indian Cotton Textile Industry* which was started from June, 1955 replaced the *Monthly Statistics of Cotton Spinning and Weaving by Indian Mills* and the monthly statistical bulletin issued for official use as *Cotton Cloth and Yarn Control in India*. The information is collected on

a statutory basis under the provisions of the Essential Commodities Act of 1955 from the units engaged in the manufacture of cotton, woollen and rayon yarn and fabrics and textile machinery. The publication gives all-India as well as State-wise figures of production of cotton yearn according to counts, cloth according to various categories and varieties, figures of import and export, annual per-capita availability of cloth, indigenous production of textile machinery and accessories, consumption and stock of cotton and cotton waste, labour employed, productivity, trade, etc. An annual publication entitled *Annual Statistical Digest, Indian Textile Industry*, is issued each year giving annual figures, together with the summary tables for a decade.

74. The monthly *Jute Bulletin* which gives data relating to jute trade and industry, statistics of production and stocks, consumption and export of jute goods, is issued by the Indian Central Jute Committee. The information is collected on a voluntary basis from the members of the Indian Jute Mills Association and hence it does not contain the data relating to units which are not members of the Association.

75. The *Monthly Coal Bulletin* contains figures of production, despatches and stocks of coal, employment, hours of work, productivity, wages, accidents, disputes, machinery installed and in operation, etc. The data are collected under the provisions of the Indian Mines Act, 1952, and the Rules framed thereunder, Coal Mines Regulations, 1957 and the Mines Maternity Benefit Act, 1941.

76. The Development Wing, Ministry of Commerce and Industry, Government of India collects monthly statistics of industrial production on a voluntary basis from industrial units registered and licensed under the Industries (Development and Regulation) Act, 1951. The units licensed are those employing 50 or more workers with the aid of power and 100 or more workers without the aid of power and engaged in the manufacture of any of the articles listed in the First Schedule to the Industries (Development of Regulations) Act, 1951. In addition to these industrial units, other organised units in the scheduled and especially assisted industries borne on the registers of the Development Wing even though not satisfying the criteria of employment and power also submit statistical returns on a voluntary basis. The returns in the first instance are collected by different Directorates of the Development Wing who are responsible for the development of their respective specific industries and these are then tabulated after scrutiny. A consolidated statement covering all industries is prepared and a copy is sent every month to the Joint Director (Industrial Statistics), Central Statistical Organisation, Department of Statistics Government of India for publication in the *Monthly Statistics of Production of Selected Industries of India* and for constructing the Index Number of Industrial Production. As compared to other agencies which collect monthly statistics, the coverage of the monthly series collected by the Development Wing is very wide and extensive.

INDEX NUMBER OF INDUSTRIAL PRODUCTION

77. Index numbers of industrial production are designed to measure at regular intervals the general movements in the volume of industrial output. The importance of index numbers in economic analysis and the various uses to which they can be put to have been described by the Statistical Commission, United Nations in the following words :

> "The general aim of an index number of industrial production is to indicate changes over time in the volume of production of non-agricultural commodities. The index numbers compress many facts into a few simple figures and, in conjunction with other data, their use in economic analysis is in summarizing past developments forecasting future trends and making decisions on policy."

> "In micro-economic analysis an index number of production shown with an industrial grouping enables comparisons to be made of changes in the output of different industries, as between themselves and in relation to such other data on separate industries as employment, wages and earnings. A specific example is the analysis of relative changes in productivity, measured statistically as output per man or per man-hour. In macro-economics, the index serves to assess the significance for the economy as a whole of changes in the volume of industrial output in relation to corresponding changes in population, national income, foreign trade, prices and other aggregates. Indeed, the index has a particular importance in any analysis of economic changes since industrial production is one of the more dynamic and fluctuating elements in the economy. The broad industrial groupings of the index are relevant here and it would be even more useful if a separation could be made, e.g., between production of capital goods and of consumption goods."

> "Activity in the whole economy of a country can be valued in three ways to give, after suitable adjustments, three identical totals: national income, national expenditure and national product. This is essentially a money valuation at current prices. However, there corresponds to each total a "real" or volume concept, with price changes eliminated, which can be approximated by a valuation at constant prices. An index of production relates to the volume concept, i.e. to national income, expenditure and product at constant prices."[7]

78. The Statistical Commission has clearly brought out the importance and significance of index numbers of industrial production in economic analysis. In an under-developed economy like India where there is a need and urge to bring about rapid industrialization, the index number of industrial production is an important economic indicator of the progress made in achieving the objective of rapid industrialization.

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[7] Statistical Commission, United Nations (1950) : Index Numbers of Industrial Production, *Studies in Methods*, Number, 1, 5.

79. The first systematic attempt at construction of index numbers of industrial production was made by Dr. D. B. Meek, in 1937. In this paper "Some Measures of Economic Activity in India"[8] read before the Royal Statistical Society on 16th March, 1937, Dr. D. B. Meek, (for some time Director of Commercial Intelligence and Statistics, Calcutta) presented a series of index numbers of industrial production for 37 years beginning from 1896-97 to 1932-33. In the construction of these indices gross value of output of following industries was used : (1) tea, (2) sugar, (3) cotton manufactures, (4) jute manufactures, (5) woollen manufactures, (6) paper and paper board, (7) breweries and distilleries, (8) iron and steel.

80. The first two industries, viz. tea and sugar were included in the index numbers of agricultural production while the remaining industries were covered in the index numbers of industrial production. These index numbers were constructed on a three-year base period (1911-12 to 1913-14) for each of the industries and the indices of individual industries were combined into an index number of industrial production by using weights proportional to the average annual value of the output of each industry during the base period. One special feature of this index number is that estimates of cotton cloth manufactured by handloom industry were prepared on the basis of yarn consumption and this was added to the production of cotton manufactures by large-scale establishments. In spite of its many defects such as inadequate coverage, incorrect and incomplete data, and other conceptual and technical shortcomings, this index number together with other indices prepared by Dr. Meek provides the necessary desideratum for measuring long-term changes in output and income. It fulfils an important historical role by providing information relating to the important sectors of the economy. Attepts have already been made to prepare estimates of long-term trends in output and income by using the information given in Dr. D. B. Meek's paper.[9]

INTERIM INDEX OF INDUSTRIAL PRODUCTION (OLD SERIES)

81. The next attempt to construct index numbers of industrial production was made by the Office of the Economic Adviser, late Department of Commerce (Ministry of Commerce and Industry), Government of India, with the year 1937 as base. It covered manufacturing, mining and electricity undertakings comprising

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[8] Meek, D. B. (1937) : *Some Measures of Economic Activity in India*, Royal Statistical Society, Part III.

[9] Mukerji, K. (1960) : A note on the long term growth of national income in India, 1900-01 to 1952-53. Paper submitted to the Second Indian Conference on Research in National Income, September, 1960.

Patel, S. J. (1958) : Long-term changes in output and income in India : 1896-1960, *The Indian Economic Journal*, 5, Number, 3.

Raj, K. N. (1961) : The growth rate of the Indian economy, 1900-1960, *Yojna*, Special Number.

the following 15 industries, which covered nearly 90 per cent of the total production of these industries.

industries	weight
1. cotton textiles	42
2. jute manufactures	18
3. steel	8
4. chemicals	1
5. paper	2
6. cement	4
7. matches	2
8. paints	1
9. wheat flour	1
10. distilleries and breweries	1
11. sugar	10
12. petrol	1
13. kerosene	1
14. coal	4
15. electricity	4
Total	100

As no census of production or manufactures was conducted, the relative weights were based on the total value of gross output during the base period. Weighted arithmetic average with fixed base was employed for the purpose of compilation of index numbers. The industries covered were cotton textiles, jute textiles, iron and steel, chemicals, paper and paper board, cement, matches, paints, wheat flour, distilleries and breweries, sugar, petrol, kerosene, coal and electricity. Adjustments for seasonal variations were made by the technique of averaging the monthly ratios of original data to a 12 month moving average during a representative period. The index was discontinued from 1949 consequent on the transfer of work relating to the compilation of monthly production statistics to the Director of Industrial Statistics, Simla.

INTERIM INDEX OF INDUSTRIAL PRODUCTION (NEW SERIES)

82. In the year, 1950 the statutory Censuses of Manufactures initiated in the year 1946 completed four years and sufficient data covering the various aspects of the industries covered were collected in these censuses to permit construction of the index numbers on a more scientific basis. It was, therefore, decided to discontinue the previous series covering 15 industries with 1937 base and introduce new series covering mining and manufacturing comprising 20 industries, with calendar year 1946 as base. It covered 35 items under 20 industries. For the first time value added by manufacture obtained from the First Census of Manufactures, 1946 was used for allotting weights to various industries. This was a definite improvement over the previous method of weighting based on the gross ex-factory value of output, as value added by manufacture measures more accurately the work done or the effort

put forth and the value created by the industry during the period. This measurement of the value of processing carried out by the industry is the true measure of its net output. In case of coal the gross ex-factory value at pit-head of coal mine was taken as an estimate of value added. The industries covered with their respective weights have been given in Table 1.

83. The index was computed by taking a simple weighted arithmetic mean. The formula was as follows

$$I = \frac{\Sigma\, Rm Wm}{\Sigma\, Wm} \times 100.$$

Where Rm is the production relative for the item for the month and Wm the weight allotted to it. The index was adjusted for variations in the number of days in the month by the formula

$$Rm = \frac{R'm \times \text{average number of days of a month in the year}}{\text{Calendar number of days in the month}}$$

Where Rm and $R'm$ were adjusted and unadjusted production relatives for the month.

84. The index was adjusted for seasonal variations in sugar industry only. Adjustment was made in the Index for the seasonal variations in its output as follows :

(a) *Production relative.* The adjusted production relative for this industry is determined by the formula

$$Rm = \frac{Pm}{pm} \times 100.$$

Where Rm is the adjusted production relative, Pm = Production during the current month and pm the production in corresponding month of the base year.

(b) *Weight.* The adjusted weight for the month is computed by the formula

$$Wm = \frac{Pm}{Am} \times 3.54.$$

Where Wm = the adjusted weight, pm = the production in the corresponding month of the base year and Am = the average monthly production in the base year. Table 1 shows the actual adjustments of weights.

85. It will be seen from Table 1 that the adjusted weight varies from month to month, being higher during the working season than during the off-season. The average weight based on the value added by the industry in the base year was 3.54, but the weights during the 8 months from April to November were less than 3.54. This deficit in the weight below 3.54 was distributed pro rata among other industries. During the months of December to March, when the weight exceeds, pro rata reduction was made in the weights for other industries. This procedure was defective in a number of ways. This procedure did not take into account the shift in the seasonal pattern in any year compared to the base year and the production in months like

TABLE 1. ADJUSTMENT OF WEIGHTS FOR SEASONAL VARIATIONS IN SUGAR INDUSTRY

	month	production in base year (tons)	adjusted weight : production in the corresponding month in the base year $\frac{\text{base year}}{76{,}908} \times 3.54$
(1)	2	3	4
1.	November, 45	18,107	0.83
2.	December, 45	161,823	7.45
3.	January, 46	287,093	13.21
4.	February, 46	250,599	11.53
5.	March, 46	158,845	7.31
6.	April, 46	33,411	1.54
7.	May, 46	6,041	0.28
8.	June, 46	1,076	0.05
9.	July, 46	Nil	—
10.	August, 46	Nil	—
11.	September, 46	1,625	0.08
12.	October, 46	4,280	0.20
	total	922,900	

July and August with zero weights. This procedure of seasonal adjustment brought about violent fluctuations in the general index number of industrial production. This was one of the major weaknesses of the index number.

REVISED INDEX OF INDUSTRIAL PRODUCTION

86. As this index number did not cover the entire production both in mining and manufacturing, it was designated as Interim Index Number of Production. In the year 1955 this series was replaced by a more comprehensive index covering mining, manufacturing and public utilities (electricity and power). It covers 88 items under the various industries of the Major Groups 11 to 51 of the International Standard Industrial Classification of all Economic Activities. The industries covered with their respective weights have been given in Table 3. The calendar year 1951 was adopted as a base year on the recommendations made by the Working Party on Base Periods of Official Index Numbers appointed by the Standing Committee of Departmental Statisticians of the Government of India. In recommending 1951 as base year, various considerations such as the new post-war norm assumed by the industries and commencement of the First Five Year Plan weighed with the Working Party. As in the case of Interim Index Number, value added by manufacture as obtained from the census of manufactures for the calendar year, 1951 was used for assigning weights to various industries covered by the census. As the scope of the census of manufactures is limited to 29 industries and to establishments employing 20 or more workers and working with the aid of power, estimates of value added for

industries not covered by the census of manufactures were made on the basis of data collected by other agencies and organisations. Weights have been allotted to the different items in proportion to the value added by manufacture.

VALUE ADDED BY MANUFACTURE HAS BEEN OBTAINED AS STATED BELOW

name of industry	source and method of estimation
(i) *manufacture of textiles :* jute textiles ; *manufacture of leather and leather products except footwear :* tanned hides ; *basic metal industries :* iron and steel, non-ferrous metals, manufacture of machinery, except electrical machines, sewing machines ;	The value added has been obtained from the Census of Indian Manufactures, 1951.
(ii) *food manufacturing industries, except beverage industries :* sugar, wheat flour, tea, salt, vegetable oil products (vanaspati) ; *tobacco manufactures :* cigarettes ; *manufacture of footwear, other wearing apparel and made up textile goods :* footwear (leather) ; *manufacture of wood and cork, except manufacture of furniture :* plywood ; *manufacture of rubber products ;* *manufacture of chemicals and chemical products :* all items except paints and varnishes, matches and soap ; *manufacture of non-metalic mineral products except products of petroleum and coal : manufacture of metal products except machinery and transport equipment ; manufacture of machinery, except electrical machines:* all items except sewing machines ; *manufacture of electrical machines apparatus, appliances and supplies :* all items except electric lamps and fans ; *manufacture of transport equipment ;* *coal mining :* coal ;	The proportion of value added by manufacture to the gross value of output for all these items except coal and salt has been determined either from the Census of Indian Manufactures, 1951 or from the sample Survey of Manufacturing Industries, 1950. For coal and salt this proportion has been determined from the particulars sent by two important concerns, and the Salt Commissioner, respectively. The value added by manufacture for all these items has been estimated by multiplying the gross value of output in 1951 by this proportion.
(iii) *manufacture of textiles :* cotton textiles ; *manufacture of chemicals and chemical products:* paints and varnishes, matches, Soaps ; *manufacture of electrical machines, apparatus, appliances and supplies :* electrical lamps and fans ;	The Census estimate of the value added by manufacture in 1951 has been increased in proportion to the excess over the census estimate of the quantity produced
(iv) *metal mining :* iron ore ;	The gross value of output in 1951 has been taken as the value added by manufacture, as the value of input is negligible.
(v) *basic metal industries :* gold ; *electric light and power:* electricity generated;	The value added by manufacture has been supplied by the Residential Auditor, Kolar Gold Field and the Department of Finance, Hyderabad, in respect of gold and by the Central Water and Power Commission in respect of electricity generated.
(vi) *manufacture of paper and paper products :* paper and paper boards.	The value added by manufacture has been obtained by multiplying the total tonnage of the production by the value added per ton of paper produced as obtained from the Census of Indian Manufactures, 1951.

87. The weights determined on the basis of values added by manufacture are distributed to the sub-items in proportion to their gross value. The cases in which census does not cover all the establishments in the industry, the census estimate of value added by manufacture is increased in proportion to the excess over the census estimate of the quantity produced either on the basis of value added as a percentage of gross output or value added per unit of physical unit, the methods of estimation being determined by availability, coverage and quality of data.

88. The monthly production statistics are collected from a wide variety of sources, as the Directorate of Industrial Statistics which conducts the annual census of manufactures and compiles the monthly index of industrial production has no organisation to collect monthly data. The monthly data are, therefore, collected from the following sources :

industries	source
1. coal	Coal Controller, Calcutta
2. iron ore	Chief Inspector of Mines in India, Dhanbad
3. sugar	Vegetable Oil Products Controller, New Delhi
4. vegetable oil products (vanaspati)	-do-
5. coffee	Indian Coffee Board, Bangalore
6. tea	Tea Board, Calcutta ; United Planters Association of Southern India, Coonoor ; and Indian Tea Association, Calcutta
7. salt	Salt Commissioner, New Delhi
8. cotton and wool	Textile Commissioner, Bombay
9. calico looms, complete ring spinning, frames and carding engines	-do-
10. jute	Indian Central Jute Committee, Calcutta
11. iron and steel	Iron and Steel Controller, Calcutta
12. gold	Geological Survey of India, Calcutta
13. electricity	Central Water and Power Commission, (Power Wing), Simla
14. other industries	Development Wing, Ministry of Commerce and Industry, New Delhi

The monthly production of different industries is estimated by these sources from the monthly returns received from factories, mining establishments, plantation and public utilities. With the exception of coal, sugar, vegetable oil (Vanaspati), salt, cotton textiles and iron and steel where the collecting agencies have statutory powers to call the returns, the information from the producers in remaining industries is called on a voluntary basis.

89. With the exception of changes in weights, coverage, base year and adjustment for seasonal variations, no changes were made in the method of computation of index number and adjustments on account of monthly variations from those described earlier in connection with the compilation of Interim Index of Industrial Production (New Series). Adjustments for seasonal variations were made by using the method of moving averages. The items sugar, salt and tea showed marked seasonal fluctuations and seasonal indices for these three industries were computed by the method of moving averages, based on the data for a period of fourteen years in the case of sugar and six years in the case of salt and tea.

The following table shows the seasonal indices for sugar, salt and tea.

TABLE 2. SEASONAL INDICES FOR SUGAR, SALT AND TEA

month	sugar	salt	tea
January	286.81	33.22	11.75
February	299.17	60.02	10.41
March	238.34	129.75	17.90
April	91.23	215.28	67.25
May	23.79	300.67	93.66
June	3.88	230.70	137.15
July	1.33	74.59	135.77
August	1.93	32.66	180.21
September	2.68	32.75	176.79
October	5.62	23.22	181.37
November	28.43	21.56	119.20
December	188.33	35.41	39.77

This procedure of adjusting the index for seasonal variations was found to be defective. It caused violent fluctuations in the general index and sugar was the chief disturbing factor. These violent fluctuations attracted good deal of attention. The index number came in for good deal of adverse comment and criticism.

90. With a view to studying the procedures for evening out the violent fluctuations and other related problems, the Central Statistical Organisation, Cabinet Secretariat, Government of India appointed a Working Group consisting of representatives of the Directorate of Industrial Statistics, the Ministry of Commerce and Industry and the Central Statistical Organisation. The Working group recommended :

(i) the present procedures of adjusting the index for the variation in the number of days in the month and for seasonal variations should be discontinued, and,

(ii) the crude index for each month should be adjusted for seasonal variations only by the seasonal indices calculated for each of the calendar months by the method of moving averages, based on the crude index calculated for each month from January 1951 to December 1958. In accordance with these recommendations, seasonal indices for each calendar month, based on the index for each of the months from January 1951 to December 1958 were computed.

The computed seasonal indices are as under :

months	seasonal index	months	seasonal index
January	103.64	July	100.57
February	100.91	August	98.85
March	103.73	September	98.22
April	99.54	October	94.93
May	99.80	November	96.75
June	96.54	December	106.75

From November 1958 the general index for every month is adjusted for seasonal variation by using the above seasonal indices.

91. Another change that has been effected is that the series of monthly production index has been extended over the latest period of 25 months instead of 13 months.

92. In spite of many changes and improvements made from time to time in the scope, coverage, base year, weighting diagram, techniques and procedures for adjustment in the seasonal variations, etc., the current index suffers from several limitations. The weighting diagram is based on the information obtained from wide variety of sources. The data obtained from all these sources for deriving weights are not of requisite quality and the data suffer from several limitations. The index is computed with 1951 as base year. It needs to be examined whether the index with 1951 as base correctly portrays the changes in industrial structure and production. The monthly production series also suffer from certain limitations which have been commented upon earlier. Firstly, with the exception of industries like coal, sugar, vegetable oil (Vanaspati), cotton and woollen textiles, iron and steel, and salt, the information is collected on a voluntary basis. The percentage response in case of many industries is between 70 to 80 per cent and this response is not uniform from month to month. Secondly, the information in case of most of the industries is collected from the large-scale units licensed under the Industries (Development and Regulation) Act, 1951, i.e., employing 50 or more workers with power and 100 or more without power. It leaves out a very large and substantial portion of industrial production from the scope of the index. Moreover, when no return is received from any unit expected to submit the return, the production for that unit is estimated. Since 1951 many new units producing capital and intermediate goods have come up, but the current index does not take cognisance of these industries. Similarly, some industries with relatively small weights have been expanding at a more rapid rate than others, but the current index with 1951 base does not take note of all such changes. It has, therefore, become imperative to revise the current index with any latest year as base. The Annual Survey of Industries which is being planned on a uniform basis simultaneously throughout India, is much wider in scope and coverage. When the data collected in this survey are processed, it may be possible to have a more reliable and representative weighting diagram. The scope and coverage of the index would be expanded automatically.

TABLE 3. INDEX NUMBERS OF INDUSTRIAL PRODUCTION IN INDIA : CLASSIFICATION OF ITEMS, VALUE ADDED BY MANUFACTURE AND WEIGHTS ALLOTTED

U.N. division (international standard classification of all economic activities)	U.N. major-group	group and sub-group	interim index number (base 1946)		present index number (base 1951)	
			value added by manufacture	weight	value added by manufacture	weight
(1)	(2)	(3)	(4)	(5)	(6)	(7)
			—	11.95	—	7.16
1. mining and quarrying	11 coal mining	11.1 coal	26,71,87,341	11.95	29,98,37,091	6.69
	12 metal mining	12.1 iron ore	—	—	2,09,36,218	0.47
						90.68
						11.85
2–3. manufacturing	20 food manufacturing industries, except beverage industries	20.1 sugar	7,91,26,680	3.54	19,14,13,904	4.27
		20.2 wheat-flour	—	—	88,78,359	0.20
		20.4 tea	—	—	26,60,38,139	5.94
		20.5 salt	—	—	3,65,99,948	0.82
		20.6 vegetable oil products (hydrogenated oil)	—	—	2,75,57,070	0.62
	22 tobacco manufactures	22.1 cigarette	—	—	6,70,00,000	1.50
						48.01
	23 manufacture of textiles	23.1 cotton textiles	97,27,34,378	43.49	1,61,76,29,967	36.10
		23.11 yarn	—	—	53,92,09,989	12.03
		23.22 cloth	—	—	1,07,84,19,978	24.07
		23.2 jute textiles	36,97,76,660	16.53	53,34,93,997	11.91
		23.3 woollen textiles	3,08,55,353	1.38	—	—
	24 manufacture of footwear, other wearing and made-up textile goods	24.1 footwear (leather)	—	—	3,81,00,000	0.85
	25 manufacture of wood and cork except manufacture of furniture	25.1 plywood	33,98,763	0.15	95,78,004	0.21
	27 manufacture of paper and paper products	27.1 paper and paper boards	3,26,70,464	1.46	7,03,11,228	1.57

TABLE 3. INDEX NUMBERS OF INDUSTRIAL PRODUCTION IN INDIA CLASSIFICATION OF ITEMS, VALUE ADDED BY MANUFACTURE AND WEIGHTS ALLOTTED—*Contd.*

U.N. division (international standard classification of all economic activities)	U. N. major-group	group and sub-group	interim index number (base 1946)		present index number (base 1951)	
			value added by manufacture	weight	value added by manufacture	weight
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	29 manufacture of leather and leather products, except foorwear	29.1 tanned hides	—	—	1,22,97,230	0.27
			—	—	15,01,01,026	3.35
	30 manufacture of rubber products	30.1 footwear (rubber)	—	—	—	0.80
		30.2 dipped rubber goods (toys, baloons, nipples, valves, teats, etc.)	—	—	—	0.02
		30.3 tyres	—	—	—	2.20
		30.4 tubes	—	—	—	0.28
		30.5 other rubber products	—	—	—	0.05
			—	—	18,65,92,407	4.16
	31 manufacture of chemicals and chemical products	31.1 sulphuric acid	—	—	—	0.20
		31.2 caustic soda	—	—	—	0.10
		31.3 soda ash	—	—	—	0.15
		31.4 chlorine liquid	—	—	—	0.03
		31.5 bleaching powder	6,94,24,629	3.10	—	0.02
		31.6 bichromates	—	—	—	0.06
		31.7 superphosphate	—	—	—	0.14
		31.8 ammonium sulphate	—	—	—	0.19
		31.11 paints and varnishes	1,35,67,483	0.61	3,47,02,713	0.77
		31.12 matches	2,69,92,879	1.21	3,88,97,728	0.87
		31.13 soap	—	—	6,18,61,707	1.38
		31.17 rayon	—	—	—	0.20
		31.18 phenol formaldehyde moulding powder	—	—	—	0.01
		31.19 liver extract	—	—	—	0.04
		31.191 injection	—	—	—	0.01
		31.192 oral	—	—	—	0.03

TABLE 3. INDEX NUMBERS OF INDUSTRIAL PRODUCTION IN INDIA CLASSIFICATION OF ITEMS, VALUE ADDED BY MANUFACTURE AND WEIGHTS ALLOTTED—*Contd.*

U.N. division (international standard classification of all economic activities)	U.N. major-group	group and sub-group	interim index number (base 1946)		present index number (base 1951)	
			value added by manufacture	weight	value added by manufacture	weight
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	33 manufacture of nonmetallic mineral products, except of petroleum and coal.		—	—	—	3.31
		33.1 glass and glassware	1,23,65,176	0.55	2,84,19,794	0.63
		33.11 sheet glass	—	—	—	0.04
		33.12 laboratory glass	—	—	—	0.03
		33.13 glass shells	—	—	—	0.01
		33.14 other glassware	—	—	—	0.55
		33.2 cement	1,49,54,020	0.67	8,29,99,454	1.85
		33.3 ceramics	—	—	2,78,55,787	0.62
		33.31 whitewares	—	—	—	0.20
		33.32 sanitarywares	—	—	—	0.01
		33.33 stonewares	—	—	—	0.10
		33.34 glazed tiles	—	—	—	0.02
		33.35 refractories	1,07,66,158	0.48	—	0.27
		33.36 insulators	—	—	—	0.02
		33.5 asbestos (cement sheets)	—	—	94,43,881	0.21
						8.04
	34 basic metal industries	34.1 iron and steel	—	—	26,51,15,131	5.92
		34.11 pig iron and ferroalloys	16,01,75,736	7.16	7,57,47,180	1.69

TABLE 3. INDEX NUMBERS OF INDUSTRIAL PRODUCTION IN INDIA CLASSIFICATION OF ITEMS, VALUE ADDED BY MANUFACTURE AND WEIGHTS ALLOTTED—*Contd.*

U.N. division (international standard classification of all economic activities)	U.N. major-group	group and sub-group	interim index number (base 1946)		present index number (base 1951)	
			value added by manufacture	weight	value added by manufacture	weight
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	34 basic metal industries	34.14 finished steel	—	—	18,93,67,951	4.23
		34.2 non-ferrous metals	—	—	5,38,14,884	1.20
		34.21 Aluminium	—	—	—	0.19
		34.23 copper (virgin metal)	4,78,36,590	2.14	—	0.34
		34.25 brass	—	—	—	0.67
		34.3 gold	—	—	4,11,04,427	0.92
	35-37 general engineering and electrical engineering		—	—	—	4.64
	35. manufacture of metal products, except machinery and transport equipment		—	—	11,52,04,501	2.57
		35.1 screws	—	—	—	0.13
		35.2 razor blades	—	—	—	0.09
		35.3 harricane lanterns	—	—	—	1.37
		35.4 oil pressure lamps	—	—	—	0.30
		35.5 enamel-ware	—	—	—	0.68
	36 manufacture of machinery, except electrical machines		—	—	2,75,26,505	0.61
		36.1 twist drills	—	—	—	0.02
		36.2 power driven pumps	—	—	—	0.13
		36.3 sewing machines	5,32,251	0.02	61,57,786	0.14
		36.4 complete ring spinning frames	—	—	—	0.05
		36.5 grinding wheels	—	—	—	0.02
		36.7 diesel engines	—	—	—	—
		36.8 machine tools	—	—	—	0.04

TABLE 3. INDEX NUMBERS OF INDUSTRIAL PRODUCTION IN INDIA CLASSIFICATION OF ITEMS, VALUE ADDED BY MANUFACTURE AND WEIGHTS ALLOTTED—*Contd.*

U.N. division (international standard classification of all economic activities)	U.N. major-group	group and sub-group	interim index number (base 1946)		present index number (base 1951)	
			value added by manufacture	weight	value added by manufacture	weight
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	37 manufacture of electrical machines, apparatus, appliances and supplies		11,32,37,113	5.06(a)	6,51,96,400	1.46
		37.1 dry cells	—	—	—	0.29
		37.2 storage batteries	—	—	—	0.10
		37.3 electric motors	—	—	—	0.13
		37.4 power transformers	—	—	—	0.09
		37.5 conduit pipes	—	—	—	0.01
		37.6 electric lamps	8,56,006	0.04	43,69,530	0.10
		37.7 electric fans	79,36,590	0.35	1,35,39,350	0.30
		37.8 radio receivers	—	—	—	0.18
		37.9 cables and wires	—	—	—	0.26
		37.91 bare copper conductors	—	—	—	0.12
		37.92 winding wires	—	—	—	0.03
		37.93 rubber and plastic insulated cables and flexibles	—	—	—	0.11
	38 manufacture of transport equipment		—	—	13,08,23,689	2.92
		38.1 automobiles	—	—	12,07,14,240	2.63
		38.2 bicycles	23,44,440	0.11	1,01,09,449	0.23
5. electricity, gas and steam	51 electric light and power	51.1 electricity generated	—	—	9,69,29,733	2.16

(*a*) General and electrical Engineering (CMI-29)

Source : *Monthly Statistics of the Production of Selected Industries of India*, May, 1954 and April, 1961.

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EVALUATION OF THE DOMINANT LATENT ROOT AND VECTOR OF A SYMMETRIC MATRIX ON CALCULATING PUNCH TYPE IBM 626

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SUMMARY. The dominant latent root and associated vector of symmetric matrices are often required in statistical and other studies. A method of such computations on the punched card system is presented in this paper. Only a sorter and calculating punch type IBM-626 or similar machine need be used.

1. Mathematical basis of the method

To evaluate the dominant latent root and the associated latent vector of a real symmetric matrix A, we adopt the method of successive approximations. First, by repetitive squaring the matrix A is raised to a high power to get

$$A^{2^m} = B = ((b_{ij})), \quad \text{say.}$$

Let $$x_i^{(0)} = \sum_{j=1}^{n} b_{ij}, \quad \text{and } y_i^{(0)} = x_i^{(0)}/x_1^{(0)}\ ; \quad i = 1, 2, \ldots, n.$$

Then $(y_1^{(0)}, y_2^{(0)}, \ldots, y_n^{(0)})$ can be taken as the initial approximation to the dominant latent vector of A.

The next approximation (which we shall call the first approximation) is $(y_1^{(1)}, y_2^{(1)}, \ldots, y_n^{(1)})$ where

$$y_1^{(1)} = x_i^{(1)}/x_1^{(1)}, \; x_i^{(1)} = \sum_{j=1}^{n} b_{ij} y_j^{(0)}$$

for $i = 1, 2, \ldots, n$. Successive approximations are obtained recursively from the formulae

$$y_i^{(t+1)} = x_i^{(t+1)}/x_1^{(t+1)}\ ; \quad x_i^{(t+1)} = \sum_{j=1}^{n} b_{ij} y_j^{(t)}$$

so that $[y_1^{(t+1)}, y_2^{(t+1)}, \ldots, y_n^{(t+1)}]$ forms the $(t+1)$-th approximation to the dominant latent vector. One stops when

$$y_i^{(t+1)} = y_i^{(t)} \qquad \text{for} \quad i = 1, 2, \ldots, n$$

to the desired degree of accuracy. If y_i is the limiting value of $y_i^{(t)}$, then $(y_1, y_2, \ldots, y_n)$ is the dominant latent vector and the dominant latent root λ is obtained from the relation

$$\lambda^{2^m} = \sum_{i=1}^{n} b_{ij} y_i / y_j.$$

2. THE SYSTEM

One punched card for each element of the matrix B showing in addition to the value 'b_{ij}' of the element, the row number i, and the column number j is prepared. This set of n^2 cards are called the matrix cards. Now we consider the matrix

$$M^{(0)} = ((m_{ij}^{(0)})),$$

where $$m_{ij}^{(0)} = y_j^{(0)}, \quad \text{for } i = 1, 2, \ldots, n \quad \text{and} \quad j = 1, 2, \ldots, n$$

and $(y_1^{(0)}, y_2^{(0)}, \ldots, y_n^{(0)})$ is the first approximation to the dominant latent vector of A. Then another set of n^2 cards, one for each element (m_{ij}) of the matrix M showing its row number i and column number j also, are prepared, which may be called multiplier cards. Also the value $x_1^{(0)} = \sum_{j=1}^{n} b_{1j}$ is punched on all the cards. The same fields are allotted to show the row numbers and column numbers in both the cases. Then the multiplier cards, the matrix cards and a set of n^2 blank cards are merged in a way specified in Section 4 and are fed into the calculating punch, so that the new multiplier values $m_{ij}^{(1)}$, with the necessary row, column identifications and cycle number, are automatically punched by the machine on the set of n^2 blank cards, which may now be called new multiplier cards. In addition the value

$$x_1^{(1)} = \sum_{j=1}^{m} b_{1j} y_j^{(0)} = (b_{11}m_{11} + b_{12}m_{12} + \ldots + b_{1n}m_{1n}),$$

is also punched on all these new multiplier cards. It is to be noted that

$$m_{ij}^{(1)} = y_j^{(1)}, \quad \text{for} \quad i = 1, 2, \ldots, n; j = 1, 2, \ldots, n \quad \text{and} \quad (y_1^{(1)}, y_2^{(1)}, \ldots, y_n^{(1)})$$

becomes the 2nd approximation to the dominant latent vector of A. Then the three sets of cards are separated by sorting on the column showing the cycle number. If $x_1^{(1)} = x_1^{(0)}$, the procedure is stopped. Otherwise, all the previous operations are repeated using the new multiplier cards in place of the old multiplier cards. The whole process is stopped when $x_1^{(t+1)} = x_1^{(t)}$, and the values of $m_{ij}^{(t+1)}$ give us the limiting value of $y_i^{(t)}$.

3. DESCRIPTION OF THE METHOD

Basic data are transferred to punched cards according to the following card designs.

CARD DESIGN FOR MATRIX CARDS

serial number	item	number of columns	card columns	remarks
1.	C.D.I.	1	1	punch 1
2.	row number	2	7–8	
3.	column number	2	9–10	
4.	value of the element (b_{ij})	5	11–15	

Note : In addition 'X' is punched in Column 7, on the card showing the element b_{1n}, and in column 9 on all the cards showing the elements $b_{i\,\overline{n-1}}$, for $i=1, \ldots, n$.

CARD DESIGN FOR MULTIPLIER CARDS

serial number	item	number of columns	card columns	remarks
1.	C.D.I.	1	1	punch 2
2.	row number	2	7–8	
3.	column number	2	9–10	
4.	value of the element (m_{ij})	5	16–20	
5.	value of x_1	7	21–27	
6.	cycle number	1	35	

Note : The above items are punched manually for the first time, and later on they are punched automatically by the calculating punch.

Procedure : The detailed steps followed by the operators are exceedingly simple. A complete operational procedure is given below.

Step (1) : The multiplier cards and the matrix cards are merged together and sorted on cols. (7–10) so that at the end of the operation, all the cards will be arranged in increasing order of row-numbers and each multiplier card is followed by corresponding matrix card having the same row and column numbers.

Step (2) : Thus the cards will be divided into 'n' groups corresponding to 'n' row identifications. At the end of each group, a set of 'n' blank cards are filed; so that we will have a pack of $(3 \times n^2)$ cards arranged in the above specified way.

Step (3) : The whole pack is now fed into the calculating punch, wherein the new multiplier values are developed and punched on the blank cards.

Step (4) : After the calculation is over the three sets of cards are separated by sorting on the column showing the cycle number.

Step (5) : Steps (1)—(4) are repeated using the new multiplier cards in place of the old multiplier cards, to obtain yet another new set of multiplier cards.

The whole procedure is stopped when $x_1^{(t+1)} = x_1^{(t)}$.

4. PROGRAMMING ON IBM CALCULATING PUNCH TYPE-626

Factor routing. (1) The value 'b_{ij}' is read from card columns 11-15 from matrix cards only (C.D.I. = 1). (2) The value 'm_{ij}' is read from card columns 16-20 from multiplier cards only (C.D.I. = 2). (3) C.D.I. = 2 is punched directly from the punch emitter on the new multiplier (blank) cards in card column 1. (4) Row numbers and column numbers are also punched in card columns 7-8 and 9-10 respectively. (5) The new multiplier values (m_{ij}) are punched in card columns 16-20. (6) The divisor x_1 is punched in card columns 21–27 on all the multiplier cards.

Read cycle operations. (1) From matrix card the information b_{ij} is read into Storage 6R. (2) From multiplier card the information m_{ij} is read into Storage 7L. (3) For all those matrix cards showing the elements $b_{1\,\overline{n-1}}, b_{2\,\overline{n-1}}, \ldots, b_{n\,\overline{n-1}}$, counters 4 and 5 are reset. (*Note* : On these cards X is punched in addition to the digit, in tens column of the field showing the column numbers by means of which a selector is picked up). (4) From all the multiplier cards showing the elements $m_{1n}, m_{2n}, \ldots, m_{nn}$, whatever information is there in the field allotted for the row number, is added to the first two positions of counter 5, which is transferred to the subsequent blank cards, on the field for column number. The cycle number from column 35 is also added in 3rd and 4th positions of counter 5, to which unity is added in the programme and the new cycle number is punched on the new multiplier cards.

Note : This is achieved by picking up a digit selector for the unit position of the number 'n'. It is to be noted that though the counter may add more than once, it retains only that information taken from the above multiplier cards for punching on the subsequent blank cards.

All these complicated ways of selection can be avoided, if we can have at least one more digit selector on the IBM-626 calculating punch.

Programme 1 *is picked up for multiplier* (m_{ij}) *cards* (C.D.I. = 2).

Programme 1 : (1) RISU Storage 6 so that Storage 6R is made ready to receive information (b_{ij}) from the matrix card. (2) Non-Punch.

Programmes 2 *and* 3 *are picked up for matrix* (b_{ij}) *cards* (C.D.I. = 1).

Programme 2 : (1) Read out Storage 6R to counters (1+2+3) and Storage 7L to multiplier unit 1. (2) Add in counters (1+2+3). (3) MPLY/DIVIDE Start 5. At this stage the sum of products ($b_{ij} \times m_{ij}$) is developed and is accumulated in counters (1+2+3).

Programme 3 : (1) RISU Storage 7, so that Storage 7L is ready to receive information (m_{ij}) from the multiplier cards. (2) Non-Punch.

Programmes 4 *to* 7 *are picked up for the matrix card showing the element* b_1n.

Programme 4 : (1) STRI.

Programmes 5 *and* 6 (coupled) : (1) Pick up co-selector 4. (2) Add 5 in counters (1+2+3) selectively in this programme through the above co-selector. Half adjustment is done at this stage. (3) Add 1 in units (not the first) position of the quotient counter (7+8). This is the value of the new multipliers (m_{i1}) for $i = 1, 2, \ldots, n$. (4) RISU Storage 3 so that the storage is made ready to receive (in the next programme) the information $x_1 = (b_{11}m_{11}+b_{12}m_{12}+\ldots+b_{1n}m_{1n})$, the constant divisor. (5) RISU Storage 4 so that the storage is also made ready to receive (in the next programme) the constant divisor, to be punched later on, on the blank cards. (6) RISU Storage 5 so that the storage is ready to receive (in the next programme) the quotient values, (which are the rest of the multiplier values) m_{ij} for $i = 1, 2, \ldots, n$ and $j = 2, 3, \ldots, n$. (7) Add 1 selectively to 3rd position of counter 5. Thus the previous cycle number which is already there in the counter is increased by unity.

Programme 7 : (1) Read out counters (1+2+3) to Storages 3 and 4. (2) Read out counters (7+8) to Storage 5 and reset. (3) Reset counters (1+2+3). (4) STRI.

Programmes 8 *to* 11 *are picked up for all those matrix cards showing the elements* b_{in} *for* $i = 2, 3, \ldots, n$.

Programme 8 : (1) STRI.

Programme 9 : (1) Read out Storage 3 to counters (1+2+3). (2) Minus in counters (1+2+3). (3) MPLY/DIVIDE Start and Divide. (4) Plus in counters (7+8).

At this stage the quotient values are developed in counters (7+8).

Programme 10 : (1) Pick up co-selector 5. (2) Plus (Add 5) in counters (7+8). Half adjustment is done. (3) Plus (Add 1) in 3rd position of counter 5. The previous cycle number is increased by unity. (4) RISU Storage 5 so that the storage is made ready to receive (in the next programme) quotient values from counters (7+8).

Programme 11: (1) Read out counters (7+8) to Storage 5 and reset. (2) Reset counters (1+2+3). (3) STRI.

Programmes 12 *to* 14 *are picked up for blank cards.*

Programme 12 : (1) Pick up co-selector 8. (2) Plus (Add 1) in counter 4. (For each blank card unity will be added so that on the first blank card 1, as row number is punched, and on the second blank card 2, so on and on the n-th blank card n is punched as row number).

Programme 13 : (1) Read out Storages 4 and 5. (2) Read out counters 4 and 5. (3) Punch through Storages 1 and 2. (4) STRI.

Programme 14 : (1) RISU Storage 7.

5. COMMENTS

The method is useful for matrices of any order for $n \leqslant 99$, of course depending on the number of digits of each element and counter capacity. Such computations can of course be done very quickly and efficiently on modern electronic computers, but the method developed here is much better than manual methods of computation. This procedure takes, remarkably less time, about ten minutes for each cycle for a matrix of size 15×15. The operational procedure is extremely simple, requires only one 626 control panel. The merging of cards in the specified way is done just with the help of a sorter, and all the information, including the cycle number is punched automatically by the calculating punch.

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EVALUATION OF POLYNOMIALS IN ONE UNKNOWN AND THEIR REAL ROOTS ON PUNCHED CARD TABULATOR TYPE IBM 421

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SUMMARY. A mechanical procedure of evaluation of polynomials in one unknown and their real roots with the help of the IBM tabulator type 421 is discussed in this paper. The author considers the equispaced values of the independent variable and applies the method of differences in evaluating the polynomials. To locate a real root of a polynomial equation in one unknown the method adopted to find a pair of consecutive values of the unknown between which the polynomial changes its sign. The interval formed by the pair then contains a root.

1. Introduction

We describe the evaluation of polynomials in one unknown and their real roots on punched card tabulator type IBM 421 using the method of differences. For simplicity a polynomial of third degree has been considered although the procedure discussed below is quite general and can be extended to the evaluation of higher degree polynomials and their real roots. The only limitation is the number of counter positions available in the tabulator.

2. Use of differences

Let $f(x) = a_3x^3+a_2x^2+a_1x+a_0$ be a polynomial of the third degree in x, which we are required to tabulate for the equispaced values $x_0, x_1, x_2, \ldots$ of x, where $x_i = x_0+ih$, h being the interval of tabulation. For simplicity, we shall write $y_i = f(x_i)$. The differences of the y_i's are defined as follows :

$$\text{first order differences : } \quad \Delta y_i = y_{i+1}-y_i$$

$$r\text{-th order differences : } \quad \Delta^r y_i = \Delta^{r-1}y_{i+1}-\Delta^{r-1}y_i$$

The third order differences are constant : $\Delta^3 y_i = 6a_3h^3$ and we shall denote this by A_3. The values of the y_i's can then be built up recursively from the relations :

$$y_{i+1} = y_i+\Delta y_i$$

$$\Delta y_{i+1} = \Delta y_i+\Delta^2 y_i$$

$$\Delta^2 y_{i+1} = \Delta^2 y_i+A_3$$

starting with the initial values :

$$A_0 = y_0$$

$$A_1 = \Delta y_0 = b_2x_0^2+b_1x_0+b_0$$

$$A_2 = \Delta^2 y_0 = c_1x_0+c_0$$

where $\quad b_2 = 3a_3h, \; b_1 = 3a_3h^2+2a_2h, \; b_0 = a_3h^3+a_2h^2+a_1h, \; c_1 = 2b_2h$

and $\quad c_0 = b_2h^2+b_1h.$

To locate a real root of the equation $f(x) = 0$, we evaluate the polynomial $f(x)$, for equispaced values of x and if the sign of $f(x)$ changes between x_i and x_{i+1} then the interval (x_i, x_{i+1}) contains a root.

How the IBM Accounting Machine Type 421 can be programmed for evaluation and location of roots using the above logic is described in the following sections.

3. MECHANISED PROCEDURE OF TABULATING THE VALUES OF $f(x)$

Using the intial value x_0 of x the values of $y_0 = f(x_0)$, Δy_0, $\Delta^2 y_0$ and $\Delta^3 y_0$ are calculated for a certain value of h. These values together with x_0, h and n are punched in a card, $(n+1)$ being the number of values of $f(x)$ to be tabulated. This card is then fed through the IBM Accounting Machine Type 421. Counters 8A, 8B, 8C, 8D, 4A, 4B and 4C are instructed to add y_0, Δy_0, $\Delta^2 y_0$ $\Delta^3 y_0$, x_0, n and h respectively. The digit 1 from digit-emitter is also entered into counter 2A. A counter is asked to plus or minus according as the number fed into it is positive or negative. For this purpose an x is punched in the card column containing the unit digit of the negative number. The tabulator is set up to start programming by a card count impulse. Three programme steps are called for and the following chart shows the operations to be carried out during these steps.

CYCLE CHART

step	operations
1	(i) read out counter 8B, plus of counter 8A (ii) read out counter 4C, plus of counter 4A
2	(i) read counter 8C, plus of counter 8B (ii) read out and print counters 4A and 8A (iii) read out counter 2A, minus of counter 4B
3	(i) read out counter 8D, plus of counter 8C (ii) reset all the counters (conditional) (iii) programme stop (conditional)

Thus at the end of the first cycle the value of the argument x and the corresponding value of $f(x)$ are formed in counters 4A and 8A respectively. In the second step first differences are formed in counter 8B and at the same time $f(x)$ and the corresponding x are printed. During this step 1 is subtracted from the content of counter 4B. As soon as counter 4B shows a negative balance a selector is picked up through its All Step pick up by a Counter Controlled All Cycles Exit Minus pulse. The selector will be picked up immediately and will remain transferred till the end of the next card feed cycle. The first operation of the third step is carried out until the selector is transferred. This operation will result in the formation of second differences in counter 8C. The second and third operations of this step are performed only when the selector is transferred. Thus the above programmes are repeated n times printing the values of $f(x_i)$and x_i where $x_i = x_0+ih$, $i = 1, 2, \ldots, n$ before the counter 4B becomes negative and the selector is transferred when the programme stops and all the counters are reset to zero. The initial values $f(x_0)$ and x_0 may be listed from the card itself.

Since in a standard 421 tabulator ten Programme Steps Counters are available, seven idle cycles will take place and hence some time will be lost between the third and the first step during the repetition of the above programmes. This difficulty can be overcome by instructing the operations in the i-th ($i = 1, 2, 3$) step to be carried out in both $(3+i)$-th and $(6+i)$-th steps. This is made possible by connecting the i-th, $(3+i)$-th and $(6+i)$-th Programme Steps Counter hubs together to one Programme Steps Out hub, the corresponding Programme Steps In hub being wired from All Cycles hub.

The total time required for tabulating $f(x_0), f(x_0+h), \ldots, f(x_0+nh)$ being approximately equal to $n/50$ minutes, this mechanical procedure becomes more worthwhile and time saving in comparison to manual computation as n becomes very large. Moreover, this method can be used in evaluating any regular function of one unknown after approximating it by a polynomial of suitable degree.

4. MECHANISED PROCEDURE OF SOLVING THE EQUATION $f(x) = 0$

The above method with some changes in programming can be used for finding the real root of the equation $f(x) = 0$. With a starting value x_0 of x and suitable value of h, the values of $f(x_0)$, $\Delta f(x_0)$, $\Delta^2 f(x_0)$ and $\Delta^3 f(x_0)$ are calculated. Then following the same procedure as discussed in Section 3, these calculated values together with x_0 and h are taken into seven counters as shown below.

input values	$f(x_0)$	$\Delta f(x_0)$	$\Delta^2 f(x_0)$	$\Delta^3 f(x_0)$	x_0	h
counter alloted	8A	8B	8C	8D	4A and 4B	4C

Following programme steps are then initiated by a card count impulse.

step	operations
1	(i) read out counter 8B, plus of counter 8A (ii) read out counter 4C, plus of counter 4B
2	(i) read out counter 8C, plus of counter 8B
3	(i) read out counter 8D, plus of counter 8C (ii) read out counter 4C, plus of counter 4A

All the three steps are repeated until the content of counter 8A changes its sign which becomes positive or negative according as the function is increasing or decreasing. To obviate this difficulty the input values are added in the counters in such a manner that irrespective of the nature of the function, the value of $f(x)$ changes its sign always from negative to positive. This is accomplished by inverting the signs of the input values of a decreasing function. As soon as counter 8A shows a positive balance an inpulse is available from the corresponding Counter Controlled All Cycles Exit Plus hub which is used to pick up a selector through its All Step pick up hub. Through the transfer side of this selector the following operations instead of the above operations are then performed in the second and third steps.

step	operations
2	(i) read out and print counters 4A and 4B
3	(i) reset all the counters (ii) programme stop

Thus counters 4A and 4B give the values x_i and x_{i+1} respectively of x such that $f(x)$ changes its sign between x_i and x_{i+1}.

5. COMMENTS

The interval of tabulation h can be taken as small as possible depending, of course, on the time needed for the entire process. Taking into consideration the fact that the maximum time required for evaluating x upto n decimal places with $h = \frac{1}{10^n}$ being approximately equal to $\frac{10^n}{50}$ minutes it will be more convenient to find x upto two decimal places as the first approximation. Then starting with the first approximate value of x and repeating the same process the second approximation upto four decimal places can be obtained. Following this iterative procedure we can locate the root upto the desired decimal places. Even if we assume that about five minutes will be spent in computing the input values and in transferring them on a card, the solution of the equation upto six decimal places can be obtained in about twenty minutes.

6. ACKNOWLEDGEMENT

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USE OF RANDOMISED ROUNDED OFF WEIGHTS IN SAMPLE SURVEYS

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SUMMARY. Use of randomised rounded off weights in large-scale sample surveys was suggested by Murthy and Sethi (1959, 1961). In this paper, two practical methods of rounding off are proposed, which leave the estimator unbiassed and are amenable to mechanised processing on punched cards. An expression for the addition to the sampling variance due to such rounding off is worked out and empirical results suggest that its magnitude is not likely to be large. Punched card methods are developed for generating such weights and for tabulation of survey data using these weights.

1. Introduction

To increase the efficiency of estimation and also to ensure a rational distribution of work-load in field operations, ultimate sample units (s.u.) in a large-scale sample survey are very often chosen with unequal probabilities. For such schemes of sampling, an unbiassed estimate of a total for the population is generally obtained as a weighted sum of the characteristics of the s.u.'s : the weight for a particular s.u. being the reciprocal of the probability of its selection. When standard punched card equipment are used in processing the data obtained from such surveys, the first stage of processing consists in passing the data-cards through a calculating punch, multiplying the s.u. characteristic by the weight, and punching the products on the cards. These product cards are next passed through a tabulator to get the required totals. This puts a considerable load on calculating punches. Also, there is the additional source of processing error in undetected wrong products.

One simple way of obviating these difficulties would be the use of self-weighted sampling designs. This is generally impracticable for several reasons : non-availability of a complete, accurate frame at the stage of drawing up the sampling design, non-response in the case of some selected s.u.'s, uneven work-load on field-investigators, inadequate precision of estimates for sub-populations etc. What is called for is clearly a method of adjustment at the stage of processing the data.

Several different methods of adjustment have been suggested by Murthy and Sethi (1959). One method is to introduce an additional stage of sampling before processing : a sample can be drawn from the selected s.u.'s and only the s.u.'s so selected are to be included in the processing; the probabilities of selection at this stage can be so adjusted that in effect the design becomes self-weighted. This would mean throwing away the information collected from s.u.'s which are later excluded from the processing. Though the sampling design can be adapted to minimise this loss, a layman is unlikely to be happy to accept this solution.

An alternative procedure is to include all the selected s.u.'s, but to round off their weights in a suitable way. Murthy and Sethi (1959) considered stochastic methods of rounding off which leave the estimator unbiassed. Later (Murthy and Sethi, 1961) they gave an iterative procedure for determining the optimum randomised rounded off weights in the sense of minimising the number of different rounded off weights when an upper bound is set for the additional sampling variance due to such rounding off. This procedure, however, is rather cumbersome for adoption in large-scale surveys.

In this paper, we present two alternative practical procedures of randomised rounding off that are amenable to mechanised processing. We round off integers, not the original weights, but the ratios they bear to the smallest weight. The rounding off is done, not in the usual arithmetical way, but in a stochastic way, so as to ensure that the estimates of totals remain unbiassed. We are thus left to work with small integral modified weights. The processing can then be done on the original cards, using the progressive digital total method on a tabulator; and for enumeration surveys, by repeated passes on a counting sorter. Of course, the simplicity of processing is achieved at the cost of some increase in the sampling variance of the estimate, but empirical results suggest that this increase in variance is more than offset by the reduction in processing costs.

In Section 2 we discuss the statistical aspects of the problem and work out an expression for the additional variance. In Section 3 methods are given for computing rounded off weights using punched card equipment. Section 4 gives simplified methods of tabulation using rounded off multipliers. Section 5 gives some empirical results about the magnitude of the additional sampling variance.

2. RANDOMISED ROUNDED OFF WEIGHTS

Let $T = \sum_{i=1}^{n} w_i y_i$ be an unbiassed estimate of a parameter θ, where y_i is a numerical characteristic of the i-th s.u., $i = 1, 2, \ldots, n$ and w_i the positive 'weight' associated with it : the weights being different for different s.u.'s.

Let $w_0 = \min(w_1, w_2, \ldots, w_n)$ and write w_i in the form

$$w_i = w_0(q_i+p_i)$$

where q_i is the largest integer not exceeding w_i/w_0 and $0 \leqslant p_i < 1$. Consider random variables $m_1, m_2, \ldots, m_n$ whose marginal distributions, given the sample, are defined by

$$\text{prob}\,(m_i = q_i) = 1-p_i$$

$$\text{prob}\,(m_i = q_i+1) = p_i. \qquad \ldots \quad (2.1)$$

We propose to use the randomised rounded off weight $w_0 m_i$ in place of w_i, so that the statistic

$$t = w_0 \sum_{i=1}^{n} m_i y_i$$

can be used, instead of T, as an estimate of θ. It follows that

$$E^*(t) = T$$

where E^* denotes conditional expectation, given the sample. Consequently t also is an unbiassed estimate of θ. The variance of t is obtained as

$$V(t) = V(T)+E(w_0^2 \sum_{i,j=1}^{n}\sum v_{ij} y_i y_j) \qquad \ldots \quad (2.2)$$

where $((v_{ij}))$ is the conditional dispersion matrix of the random vector $m = (m_1, m_2, \ldots, m_n)$. The second term on the right hand side of (2.2) represents the additional variance due to the use of randomised rounded off weights. Obviously

$$v_{ii} = p_i(1-p_i), \;\; i = 1, 2, \ldots, n$$

but the values of v_{ij} for $i \neq j$ will depend on the bivariate marginal distributions of the random variables $m_1, m_2, \ldots, m_n$.

The random vector m can be generated in many different ways. In this paper we shall consider two particular methods, to be called (i) independent and (ii) systematic methods of generation which can be readily mechanised. In method (i), given the sample, the random variables $m_1, m_2, \ldots, m_n$ are generated independently, so that

$$v_{ij} = 0 \quad \text{for} \quad i \neq j.$$

This can be done by taking independent random variables $x_1, x_2, \ldots, x_n$ each distributed uniformly in (0, 1) and defining m_i as the largest integer not exceeding $p_i+q_i+x_i$. Hence, if we denote by t_1 the estimate obtained with this set of randomised rounded off weights, we get

$$V(t_1) = V(T)+E[w_0^2 \sum_{i=1}^{n} y_i^2\, p_i(1-p_i)]. \quad \ldots \quad (2.3)$$

In method (ii), the random vector m is generated in the following way.

Let

$$W_1 = w_1,\; W_2 = w_1+w_2, \ldots, W_n = w_1+w_2+\ldots+w_n.$$

We write

$$W_i = w_0(Q_i+P_i)$$

where Q_i is the largest integer not exceeding W_i/w_0 and $0 \leqslant P_i < 1$. Let x be a random variable distributed uniformly in (0, 1) and independently of the sample selected. Let M_i be the largest integer not exceeding $\left(\frac{W_i}{w_0}+x\right)$. We then define

$$\begin{aligned} m_1 &= M_1 \\ m_i &= M_i - M_{i-1}, \quad i = 2, 3, \ldots, n. \end{aligned} \quad \ldots \quad (2.4)$$

The random vector $m = (m_1, m_2, \ldots, m_n)$ so defined is immediately seen to satisfy the condition (2.1). A little calculation shows that

$$v_{ij} = \Delta_{ij} - \delta_i\delta_j, \quad i \neq j = 1, 2, \ldots, n \quad \ldots \quad (2.5)$$

where

$$\begin{aligned} \delta_i &= P_i - P_{i-1} \\ \Delta_{ij} &= P_{ij} - P_{i,j-1} - P_{i-1,j} + P_{i-1,j-1} \end{aligned}$$

P_{ij} being defined as the smaller of P_i and P_j and for the purpose of these definitions $P_0 = 0$. If in particular the groups are so arranged that $P_1 \leqslant P_2 \leqslant \ldots \leqslant P_n$, then $\delta_i = p_i$ and $\Delta_{ij} = 0$, so that $v_{ij} = -p_ip_j$ for $i \neq j = 1, 2, \ldots, n$. If we denote by t_2, the estimate obtained with weights rounded off this way, we get

$$V(t_2) = V(T)+E\Big[w_0^2\Big\{\sum_{i=1}^{n} y_i^2\, p_i-\Big(\sum_{i=1}^{n} y_i p_i\Big)^2\Big\}\Big], \qquad \ldots \quad (2.6)$$

Thus from (2.3) and (2.6)

$$V(t_1)-V(t_2) = E\Big[\; w_0^2 \sum_{i\neq j=1}^{n}\sum y_i y_j p_i p_j\Big]$$

which must be non-negative if $y_i \geqslant 0$ for $i = 1, 2, \ldots, n$. It follows therefore that method (ii) of randomised rounding off is better than method (i) when the groups are arranged in ascending order of the values of their P_i's. In practice, however, it is possible to get such an arrangement only if $\sum_{i=1}^{n} p_i < 1$.

3. PUNCHED CARD METHOD FOR COMPUTING RANDOMISED ROUNDED OFF WEIGHTS

Standard punched card equipment can be used with advantage for computing randomised rounded off weights, whenever the number of sample units is large. One starts with a deck of punched cards (one card per sample unit) giving the indentification number of the 's.u.' and its 'weight' w.

For rounding off the weights with independent binomial probabilities using method (i), one has to take another deck of punched cards on each one of which a random number distributed uniformly in the interval (0, 1) is punched. The two decks are collated in such a way that each 's.u. card' is preceded by a 'random number card.' This merged pack is sent into a calculating punch. From each 's.u.' card the weight 'w_i' is taken to a counter, divided by the minimum weight w_0 supplied by digit emitter and to the fractional part of the quotient formed, the random number x_i from the corresponding random number card is added. The integral part of this total is the required randomised rounded off weight m_i and it is punched on the corresponding 's.u.' card in an assigned field. The counters are cleared for each card.

For computing the randomised rounded off weights using method (ii) the deck of s.u. cards is sorted in the order in which the units were sampled and is fed into the calculating punch. As the first s.u. card passes through the machine, w_1 is taken into the dividend counter. It is divided by w_0 and the quotient formed in a pair of counters coupled together so that the integral part of the quotient will be formed in the least significant positions of the higher order counter and fractional part in the lower order counter. To this fractional part is added the random number x $(0 < x < 1)$ from the digit emitter and the integral part is punched as 'm_i'. The higher order quotient counter is now cleared but not the lower order quotient counter nor the dividend counter. From the second 's.u.' card w_2 is added to the remainder left over in the dividend counter and this net figure is divided by w_0. The integral part of the quotient formed is m_2 and is punched in the assigned columns. The process is continued for the rest of the cards, clearing each time only the higher order counter allotted for quotient.

4. SIMPLIFIED METHODS OF TABULATION WITH RANDOMISED ROUNDED OFF WEIGHTS

In most cases, the types of estimates required are obtained as the weighted sum of observed values of characteristics of sampled units belonging to each of many different classificatory groups. Randomised rounding off the weights leaves us with weights which are mostly single digit figures and sometimes two-digit figures which can be split up to two single digit numbers adding to that number. Multiplication by these single digit weights of the observed value and summing them over units belonging to each classificatory group becomes quite simple and the need for calculating punches can altogether be eliminated at this stage.

The weighted sums can be obtained on the tabulator itself by applying the progressive digital method.

One starts with a pack of punched cards, one card for each 's.u.' containing the identification number, classificatory codes, the characteristics, and the randomised rounded off weight m_i. We assume that the rounded off weights are all single digit numbers and hence are punched in a single column field. These cards are sorted in descending order of the rounded weights and fed into the tabulator. Every gap in the sequence between 1 and the maximum rounded weight must be filled by inserting blank cards. The machine is set to add the characteristic values 'y' and controlled on the weight. At every break of control the cumulated sum of y's is transferred to another counter without resetting the first counter. The final total accumulated in the second counter after all the 's.u. cards have passed through the machine is the required weighted sum and it is printed out or summary punched as desired. The weighted sums for different classificatory groups are obtained by distributing the y-field among different sets of counters.

When the characteristics are simply indicator variables, that is when each y takes the value 1 or 0 according as the s.u. has a certain attribute or not, the tabulating machine can be dispensed with. A sort counting machine of the IBM type 101-Electronic Statistical Machine can be used with advantage. The Electronic Statistical Machine (ESM) has a feeding speed of 450 cards per minute which is almost thrice that of a tabulator and in addition has about sixty sets of recode selectors and unit counters for purposes of distribution and counting. The problem now reduces to adding up the rounded off weights of the s.u.'s separately for the different classificatory groups. The cards are fed into the machine and the machine is instructed to count the number of cards belonging to different groups. Cards are repeatedly passed through the machine so that any 's.u.' card having weight r passes through the machine r-times and gets counted r-times. This is done by instructing the ESM to sort the cards according to the weights, and at the same time count the number of cards in each group. At the end of j-th run all the 's.u.' cards which fall in the pockets 1, 2, 3, ..., j are removed and the rest of the cards fed into the machine for the $(j+1)$-th run. If the weights range from 1 to 9, this will involve 9 runs. In case the maximum weight is less than 9 say m only, then the operation terminates after m runs, and the total in the respective counters are printed out. This process has many built-in checks. The ESM itself is equipped to cross-foot check the totals held in the different counters. Also any mis-sorting which is not systematic can be detected by this repetitive removing of some cards and sorting the result again. For instance, if during the third run we get some cards in pocket number 1 or 2 it indicates missorting at some stage and further work on wrong lines can be stopped forthwith. It should also be noted that though there may be 9 runs of cards through the machine not all the cards are run through the machine nine times. At each stage a part of the pack of cards is removed and only the rest run again.

Our experience is that the number of card passages is likely to be of the order of three times the number of cards in most practical applications. The cost of this additional card passage is more than offset by the higher speed and larger counter capacity of the ESM.

5. NUMERICAL EXAMPLES

From a list of 54 districts of the State of Uttar Pradesh which gives, for each district, the area in square miles and the population according to the 1961 census, a sample of 10 districts was selected one by one with replacement, in such a way that the probability of selecting any district, in a particular draw, was proportional to the area of the district.

An unbiassed estimate of θ, the total population of the State is then obtained as $T = \sum_{i=1}^{10} y_i w_i$ where y_i is the population of the i-th selected district and $w_i = (1/10)$ (A/a_i) where $A = 113453$ sq. miles is the total area of the State and a_i is the area in sq. miles of the i-th selected village.

Table 5.1 gives these statistics and also shows the computation of the randomised rounded off multipliers $m_i^{(1)}$ and $m_i^{(2)}$ by the two methods. The modified estimates are then obtained as

$$t_1 = w_0 \sum_{i=1}^{10} y_i m_i^{(1)} \text{ (by `independent' rounding off)},$$

and,

$$t_2 = w_0 \sum_{i=1}^{10} y_i m_i^{(2)} \text{ (by `systematic' rounding off)},$$

where $w_0 = \min (w_1, w_2 \ldots, w_{10}) = 2.918030$.

We thus obtain $T = 7.962 \times 10^7$, $t_1 = 8.120 \times 10^7$, $t_2 = 7.752 \times 10^7$ as estimates of the parameter $\theta = 7.375 \times 10^7$.

TABLE 5.1. GENERATION OF RANDOMISED ROUNDED OFF WEIGHTS BY TWO METHODS

population and area				method (i)			method (ii)		
i	y_i (thousands)	a_i (sq. miles)	$w_i=A/10a_i$	w_i/w_0	x_i	$m_i^{(1)}$	W_i/w_0	M_i	$m_i^{(2)}$
1	1728	1543	7.352754	2.5198	0.5261	3	2.5198	3	3
2	1086	3888	2.918030	1.0000	0.3853	1	3.5198	4	1
3	1616	2236	5.073927	1.7388	0.2679	2	5.2586	5	1
4	1860	1816	6.096346	2.0892	0.7840	2	7.3478	7	2
5	1227	1774	6.395321	2.1917	0.3412	2	9.5395	10	3
6	2372	2087	5.436176	1.8630	0.5685	2	11.4025	11	1
7	1498	2620	4.330267	1.4840	0.1264	1	12.8865	13	2
8	1736	1887	6.012347	2.0604	0.3816	2	14.9469	15	2
9	430	1201	9.446544	3.2373	0.7334	3	18.1842	18	3
10	574	2626	4.320373	1.4806	0.9928	2	19.6648	20	2

$A=113453$ sq.miles ; $w_0=2.918030$; $(W_i = \sum_{x=1}^{i} w_x$; $x=0.5261)$.

An estimate of the variance of T is obtained as

$$\text{est } V(T) = \frac{1}{9}\left[10 \sum_{i=1}^{10} (y_i w_i)^2 - T^2\right] = 1.4983 \times 10^{14}.$$

An estimate of the additional variance in $t^{(1)}$ due to rounding off the multipliers by method (i) is obtained as

$$w_0^2 \sum_{i=1}^{10} y_i^2 p_i (1-p_i) = 0.2789 \times 10^{14}$$

where p_i is the fractional part of w_i/w_0. Thus an estimate of the variance of $t^{(1)}$ is

$$\text{est } V(t_1) = \text{est } V(T) + w_0^2 \sum_{i=1}^{10} y_i^2 p_i \ (1-p_i) = 1.7772 \times 10^{14}$$

which means that rounding off by method (i) causes an increase of only about 9.3% in the standard error of the estimate.

An estimate of the additional variance in t_2 due to rounding off the multipliers by method (ii) is given by

$$w_0^2 \left[\sum_{i,j=1}^{10} \Delta_{ij} \, y_i y_j - \left(\sum_{i=1}^{10} \delta_i y_i \right)^2 \right]$$

$$= 0.02585 \times 10^{14}.$$

Thus

$$\text{est } V(t_2) = 1.5242 \times 10^{14}$$

which means that rounding off by method (ii) causes an increase of only 1.2% in the standard error of the estimate. The details of the computation are shown in Tables 5.2 and 5.3.

TABLE 5.2. VALUES OF $P_{i,j}$ AND P_i

i/j	1	2	3	4	5	6	7	8	9	10	P_i
1	0.5198	0.5198	0.2586	0.3478	0.5198	0.4025	0.5198	0.5198	0.1842	0.5198	0.5198
2	0.5198	0.5198	0.2586	0.3478	0.5198	0.4025	0.5198	0.5198	0.1842	0.5198	0.5198
3	0.2586	0.2586	0.2586	0.2586	0.2586	0.2586	0.2586	0.2586	0.1842	0.2586	0.2586
4	0.3478	0.3478	0.2586	0.3478	0.3478	0.3478	0.3478	0.3478	0.1842	0.3478	0.3478
5	0.5198	0.5198	0.2586	0.3478	0.5395	0.4025	0.5395	0.5395	0.1842	0.5395	0.5395
6	0.4025	0.4025	0.2586	0.3478	0.4025	0.4025	0.4025	0.4025	0.1842	0.4025	0.4025
7	0.5198	0.5198	0.2586	0.3478	0.5395	0.4025	0.8865	0.8865	0.1842	0.6648	0.8865
8	0.5198	0.5198	0.2586	0.3478	0.5395	0.4025	0.8865	0.9469	0.1842	0.6648	0.9469
9	0.1842	0.1842	0.1842	0.1842	0.1842	0.1842	0.1842	0.1842	0.1842	0.1842	0.1842
10	0.5198	0.5198	0.2586	0.3478	0.5395	0.4025	0.6648	0.6648	0.1842	0.6648	0.6648
P_j	0.5198	0.5198	0.2586	0.3478	0.5395	0.4025	0.8865	0.9469	0.1842	0.6648	—

TABLE 5.3. VALUES OF Δ_{ij} AND δ_i

i/j	1	2	3	4	5	6	7	8	9	10	δ_i
1	0.5198	0.	−0.2612	0.0892	0.1720	−0.1174	0.1174	0.	−0.3357	0.3357	0.5198
2		0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
3			0.2612	.0.0892	−0.1720	0.1174	−0.1174	0.	0.2612	−0.2612	−0.2612
4				0.0892	0.	0.	0.	0.	−0.0892	0.0892	0.0892
5					0.1916	−0.1370	0.1370	0.	−0.1916	0.1916	0.1916
6						0.1370	−0.1370	0.	0.1370	−0.1370	−0.1370
7							0.4840	0.	−0.4840	0.2623	0.4840
8								0.0604	−0.0604	0.	0.0604
9									0.7627	−0.4806	−0.7627
10										0.4806	0.4806

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SOLUTION OF A CLASS OF PROGRAMMING PROBLEMS

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SUMMARY. The paper shows that a wide class of Programming Problems can be reduced to a number of simpler problems that can be solved by the method of Lagrange's multipliers. The results have a very wide application. Examples of application are the problems of allocation of sample size to different strata or to different stages or to different phases in a multi-purpose sample survey.

1. INTRODUCTION

Most of the problems in statistics are concerned with maximizing or minimizing some function under one or more equality or inequality restrictions. When the restrictions are equalities the problems can very often be solved by the method of Lagrange's multipliers. If some of the restrictions are inequalities we call it a Programming Problem and it is generally more difficult to solve. The particular case when the restrictions are linear has been extensively studied under the title of Linear Programming. It is the purpose of the present paper to show that a much more general class of programming problems can be reduced to the solution of problems which involve only equality restrictions.

2. PROGRAMMING PROBLEM (1)

Find the minima of $f(x)$ with respect to x given that

$$x \epsilon A = \bigcap_{i=0}^{m} Ai \qquad \dots \quad (1)$$

where

$$A_0 = \{x \mid x \geqslant 0\} \qquad \dots \quad (2)$$

$$Ai = \{x \mid g_i(x) \leqslant bi\}, \quad (i = 1, 2, \dots, m) \qquad \dots \quad (3)$$

and

$$x = (x_1, x_2, \dots, x_n). \qquad \dots \quad (4)$$

Definition : A point P in A will be called a minimum of $f(x)$ in A if there exists an interval I containing P such that $f(P) < f(x)$ for all $x \epsilon (I \bigcap A) - (P)$.

The particular class of programming problems considered here imposes some restrictions on the functions $f(x)$, $g_1(x)$, $g_2(x)$, ..., and $g_m(x)$.

(a) Throughout the region $A f(x)$, $g_1(x)$, $g_2(x)$, ..., and $g_m(x)$ are continuous.

(b) $f(x)$ is bounded below in A and is strictly decreasing in at least one of the coordinates of x.

3. LEMMAS

Lemma 1 : *If there is any solution* x' *of Problem* (1), *it must satisfy the following condition :*

$$x' \epsilon B = A \bigcap \left(\bigcup_{i=1}^{m} B_i \right) \qquad \dots \quad (5)$$

where

$$B_i = \{x \mid g_i(x) = b\}. \qquad \dots \quad (6)$$

Proof : Let us consider a point $x \epsilon (A-B)$, i.e., x satisfy the conditions

$$x \geqslant 0 \qquad \dots \quad (7)$$

and

$$g_i(x) < b_i, \quad (i = 1, 2, \dots, m). \qquad \dots \quad (8)$$

Let x_j be the coordinate for which $f(x)$ is strictly decreasing in A. Keeping all the coordinates fixed we can increase x_j slightly such that conditions (8) continue to be satisfied. Call this new point x'. As $f(x)$ is strictly decreasing in x

$$f(x) > f(x'). \qquad \dots \quad (9)$$

Thus no point can be a solution of Problem (1) unless it belongs to B.

Note : In the proof above it is not necessary to assume continuity of all the functions $f(x)$, $g_1(x)$, $g_2(x)$, $\dots, g_m(x)$. It is enough if all these are continuous to the right in x_j.

Lemma 2 : *If* x' *is a minimum of* $f(x)$ *in a region* C_1 *such that*

$$x' \epsilon C_2 \subset C_1 \qquad \dots \quad (10)$$

then x' *is also a minimum of* $f(x)$ *in* C_2.

Proof : As x' is a minimum of $f(x)$ in C_1, there exists an interval I such that $f(x) > f(x')$ for all $x \epsilon (C_1 \bigcap I) - (x')$.

As $\quad C_2 \subset C_1, \ (C_2 \bigcap I) - (x') \subset (C_1 \bigcap I) - (x')$

thus for all $\ x \epsilon (C_2 \bigcap I) - (x')$

$$f(x') < f(x)$$

and so by definition x' is a minimum of $f(x)$ in C_2.

Corollary : *Let* x_w *denote a point where* $f(x)$ *is minimized in the region* $A0 \bigcap_{i \epsilon w} Ai$. *If* x_w *belongs to* A, *it is also a minimum of* $f(x)$ *in* A.

Lemma 3 : *If* P *is a minimum of* $f(x)$ *in* A *and it belongs to some region* $A0 \bigcap_{i \epsilon w} Bi$. *then either* P *is a minimum of* $f(x)$ *in* $A0 \bigcap_{i \epsilon w} Bi$ *or it also belongs to some* B_j, $j \notin w$.

Proof : Let there be some interval I' containing P such that

$$I' \bigcap A0 \bigcap_{i \epsilon w} Ai = I' \bigcap A.$$

As P is a minimum of $f(x)$ in A, there is some interval I containing P such that

$$f(x) > f(P) \quad \text{for all } x \epsilon (I \bigcap A) - (P).$$

So $$f(x) > f(P) \text{ for all } x \epsilon (I \bigcap I' \bigcap A) - (P) = (I \bigcap I' \bigcap A0 \bigcap_{i \epsilon w} Ai) - (P).$$

Hence P is a minimum of $A0 \bigcap_{i\epsilon w} Ai$ and so, by Lemma 2, of $A0 \bigcap_{\epsilon w} Bi$.

Let there be no interval I' containing P for which

$$I' \bigcap A0 \bigcap_{i\epsilon w} Ai = I' \bigcap A.$$

In this case every neighbourhood of P must have at least one point belonging to the compliment of $\bigcap_{i \notin w} Ai$. Thus in every neighbourhood of P, at least one of the functions $g_j(x)$, $j \notin w$, must assume a value greater than bj at some point. As $P \epsilon Aj$, $g_j(P) \leqslant bj$. If $g_j(P) < bj$ and $g_j(x)$ is continuous at P, then we can find a neighbourhood of P throughout which $g_j(x) < bj$. As this is not the case, $g_j(P) = bj$. Thus P belongs to Bj, $j \notin w$.

4. SOLUTION OF PROBLEM (1)

We can solve Problem (1) by the following steps :

Step (1) : Find the minima of $f(x)$ on $A0 \bigcap Bj$, $(j = 1, 2, \ldots, m)$. If some of them belong to A, they are also minima of $f(x)$ in A.

Step (2) : Find the minima of $f(x)$ on $A0 \bigcap Bj \bigcap Bj'$. $(j \neq j' = 1, 2, \ldots, m)$. If some of these points belong to A they are also minima of $f(x)$ in A. Proceed step by step increasing the number of restrictions. In this way all the minima of $f(x)$ in A are obtained. The absolute minimum, if required, can be found by comparing the values of $f(x)$ at these various minima.

Note (1) : If some Ai is defined by $\{x \,|\, g_i(x) \geqslant bi\}$ it can be redefined by $\{x \,|\, g_i'(x) \leqslant b_i'\}$, where $g_i'(x) = g_i(x)$ and $bi' = -bi$. Thus the definition of Ai as given in Problem (1) is quite general.

Note (2) : Let some of the restrictions, say 1 to k, in Problem (1) be equalities. This means that

$$x \epsilon A = A0 \bigcap_{i=1}^{k} Bi \bigcap_{j=k+1}^{m} Aj.$$

The solution of the problem will then remain essentially the same. Only the first step will be to find the minima of $f(x)$ on the surface $A0 \bigcap_{i=1}^{k} Bi$ and in the subsequent steps we take additional Bj's from $j = k+1$, $k+2$, $\ldots$, m only.

5. PROBLEM (2)

Find the maxima of $f(x)$ with respect to x given that

$$x \epsilon A = \bigcap_{=0}^{m} Ai$$

where Ai's are defined as in Problem (1) and the restriction (a) of Problem (1) is satisfied. Restriction (b) is, however, changed to (b') $f(x)$ is bounded above in A and is strictly increasing in at least one of the coordinates of x.

The solution of Problem (2) can be found by the same method as outlined in Section 5. The word "minima" has to be replaced by "maxima". The proof requires minor modifications in the lemmas proved above. These are obvious and need not be discussed in detail here.

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A NOTE ON INTERPENETRATING SUB-SAMPLES OF UNEQUAL SIZES

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SUMMARY. In this note the problem of estimation from interpenetrating sub-samples of unequal sizes is investigated empirically. For several reasons it seems desirable to give equal weightage to sub-sample estimates even when there are marked differences in sub-sample sizes.

1. INTRODUCTION

Interpenetrating sub-samples are usually designed to be both independent and of equal size. However, due to differential response to the designed sub-samples, their sizes may not remain equal at the stage of tabulation. It could also be visualized that deliberate variations of the sub-sample sizes, while designing the survey, would allow for greater flexibility in the allocation of the sub-samples to field agencies or tabulation units capable of handling unequal volumes of work. Similarly, if the restriction of the equality of the sizes of sub-samples is removed, the first sub-sample can be designed deliberately to have the appropriate size for giving advance estimates of required precision.* In this note we examine the status of three methods of combining estimates based on sub-samples of unequal sizes.

2. ESTIMATION FROM UNEQUAL SUB-SAMPLES

Based on each of k interpenetrating sub-samples of unequal sizes, we may give independent and unbiassed estimates of the population value with different sampling variabilities. Thus we have sub-sample estimates

$$x_1, x_2, \ldots, x_k,$$

with

$$E(x_i) = \mu \quad \text{and} \quad \text{var}(x_i) = \sigma_i^2, \quad i = 1(1)k;$$

$$\text{cov}(x_i, x_j) = 0 \quad \text{for } i \neq j.$$

The pooled estimate is

$$x = \sum_1^k w_i x_i, \quad \sum_1^k w_i = 1 \qquad \ldots \quad (2.1)$$

where

$$E(x) = \mu \qquad \ldots \quad (2.2)$$

and

$$\text{var}(x) = \sigma^2 = \sum_1^k w_i^2 \sigma_i^2. \qquad \ldots \quad (2.3)$$

Defining the estimate of variance as

$$s^2 = \left\{ \sum_1^k w_i^2 x_i^2 - \left(\sum_1^k w_i^2 \right) x^2 \right\} \Big/ \left\{ 1 - \left(\sum_1^k w_i^2 \right) \right\}, \qquad \ldots \quad (2.4)$$

we have

$$E(s^2) = \sum_1^k w_i^2 \sigma_i^2 = \sigma^2. \qquad \ldots \quad (2.5)$$

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*These two requirements are met at present by taking basic sub-samples of sufficiently small but equal size and using appropriate multiples of them, e.g., using the first two sub-samples for preliminary tabulations.

Incidentally, it may be noted that the range determined by $(x_1, x_2, \ldots, x_k)$ provides a confidence interval for 'μ' (when it is equal to the median value) at probability level $1-(1/2)^{k-1}$ even if $\sigma_1^2 \neq \sigma_2^2 \neq \cdots \neq \sigma_k^2$. Now, we examine empirically the status of different systems of weights in the following section.

3. SOURCE OF DATA

The relative advantages and disadvantages of different systems of weighting the sub-sample estimates have been empirically examined on the basis of the National Sample Survey (NSS) data. For this purpose we have considered the estimates given in the Reports on the National Sample Survey : Number 10 (1958a) and Number 36 (1961) based on the eighth round data ; and Number 13 (1958b) based on the seventh round data. The details of the sampling design are broadly as follows. In the seventh round a stratified three-stage design was used in rural areas—tehsils, villages and households being the sampling units in the successive stages. The tehsils were first grouped into 240 strata and two sample tehsils were chosen from each stratum with probability proportional to population or area (PPP(A)) and with replacement. Two sample villages were chosen again with PPP(A) with replacement from each sampled tehsil. Finally, the transport households were listed in the chosen village and a systematic sample of ten selected.

In urban areas a similar three-stage selection was made—towns, blocks and households being the sampling units in the successive stages. Towns were stratified by regions and by population and selected with PPP and with replacement. The metropolitan areas were preferentially included in the sample. From each selected town, blocks were chosen with probability proportional to total number of households and with replacement. The procedure of selection of households within blocks was similar to that of households within villages. Sub-sample estimates I and II from this round are used in the empirical study.

In the eighth round a stratified two-stage sampling procedure was used in rural areas—villages and households being the sampling units in the successive stages. The villages were first allocated to the States and then to 'natural divisions' (as defined in the 1951 census) on the basis of suitable criteria. Tehsils were grouped into 356 homogeneous strata and from each stratum a multiple of four villages was drawn in Central and State samples with PPP(A) with replacement. Households in selected villages were listed and stratified into three types by extent of land ownership and livelihood class. A suitable number of households were selected systematically from each type so that twenty to twenty-four households were selected per village and the estimates by types were self-weighting. Four independent sub-samples were selected for the Central sample and eight for the State sample. We have conducted our empiric investigation on the basis of (a) Central sub-samples I and II, (b) Central sub-sample I and combined Central sub-samples II, III and IV, and (c) combined State sub-samples I to III and combined State sub-samples IV to VIII. These provide pairs of interpenetrating samples of varying sizes.

TABLE 1. POOLED ESTIMATES WITH STANDARD ERRORS OF PAIRS OF INTERPENETRATING SUB-SAMPLES USING (1) EQUAL WEIGHTS, (2) WEIGHTS IN PROPORTION TO SAMPLE VILLAGES AND (3) WEIGHTS IN PROPORTION TO SAMPLE HOUSEHOLDS

character	sample size				estimate and standard error		
	villages/blocks		households		equal weights	weights in proportion to sample villages/blocks	weights in proportion to sample households
	sub-sample I	sub-sample II	sub-sample I	sub-sample II			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1. % of households owning $<$ 1.50 acres[1]	353	351	6118	6362	52.20 ± 0.61	52.20 ± 0.44	52.21 ± 1.27
2. % of households owning $<$ 2.50 acres[1]	353	351	6118	6362	60.78 ± 0.63	60.78 ± 0.42	60.79 ± 1.38
3. % of households operating $<$ 1.50 acres[2]	353	351	6118	6362	45.49 ± 0.30	45.49 ± 0.41	$45.48\pm\sqrt{-0.45}$[a]
4. % of households operating $<$ 2.50 acres[2]	353	351	6118	6362	54.79 ± 0.85	54.79 ± 1.00	$54.77\pm\sqrt{-1.10}$[a]
5. % of area held by households owning $<$ 1.50 acres[1]	353	351	6118	6362	2.76 ± 0.07	2.76 ± 0.08	$2.76\pm\sqrt{-0.00}$[a]
6. % of area held by households owning $<$ 2.50 acres[1]	353	351	6118	6362	6.32 ± 0.17	6.33 ± 0.18	$6.32\pm\sqrt{-0.01}$[a]
7. % of area held by households operating $<$ 1.50 acres[2]	353	351	6118	6362	2.47 ± 0.12	2.47 ± 0.13	2.47 ± 0.05
8. % of area held by households operating $<$ 2.50 acres[2]	353	351	6118	6362	5.96 ± 0.53	5.97 ± 0.55	5.94 ± 0.40
9. number of households engaged in rural transport enterprise (lakhs)[3]	479	480	1415	1327	10.61 ± 0.49	10.60 ± 0.48	10.62 ± 0.76
10. number of persons per working day in rural transport enterprise (lakhs)[3]	479	480	1415	1327	6.70 ± 1.11	6.70 ± 1.10	6.74 ± 1.30
11. value of fixed capital in rural transport enterprise (rupees lakhs)[3]	479	480	1415	1327	5089.87 ± 421.52	5089.43 ± 416.19	5103.39 ± 561.77
12. monthly gross earnings in rural transport enterprise (rupees lakhs)[3]	479	480	1415	1327	240.80 ± 34.94	240.77 ± 34.68	241.93 ± 41.97

See footnotes on p. 348.

TABLE 1. POOLED ESTIMATES WITH STANDARD ERRORS OF PAIRS OF INTERPENETRATING SUB-SAMPLES USING (1) EQUAL WEIGHTS, (2) WEIGHTS IN PROPORTION TO SAMPLE VILLAGES AND (3) WEIGHTS IN PROPORTION TO SAMPLE HOUSEHOLDS —(*Contd.*)

character	sample size				estimate and standard error		
	villages/blocks		households		equal weights	weights in proportion to sample villages/blocks	weights in proportion to sample households
	sub-sample I	sub-sample II	sub-sample I	sub-sample II			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
13. number of households engaged in urban transport enterprise (lakhs)[4]	226	217	885	767	4.03 ± 0.14	4.04 ± 0.20	4.04 ± 0.31
14. number of persons per working day in urban transport enterprise (lakhs)[4]	226	217	885	767	4.60 ± 0.43	4.59 ± 0.32	$4.57\pm\sqrt{-0.10}^{a}$
15. value of fixed capital in urban transport enterprise (rupees lakhs)[4]	226	217	885	767	1970.73 ± 546.87	1959.62 ± 505.37	1932.67 ± 382.93
16. monthly gross earnings in urban transport enterprise (rupees lakhs)[4]	226	217	885	767	342.36 ± 59.76	323.14 ± 52.78	320.09 ± 28.65
17. % of households owning < 1.50 acres[5]	353	1057	6118	18248	52.47 ± 0.88	52.91 ± 6.87	52.91 ± 6.86
18. % of households owning < 5.00 acres[5]	353	1057	6118	18248	74.45 ± 0.83	74.87 ± 7.93	74.87 ± 7.92
19. % of area held by households owning < 1.50 acres[5]	353	1057	6118	18248	2.79 ± 0.04	$2.78\pm\sqrt{-0.10}^{a}$	$2.78\pm\sqrt{-0.10}^{a}$
20. % of area held by households owning < 5.00 acres[5]	353	1057	6118	18248	16.75 ± 0.31	$16.60\pm\sqrt{-5.01}^{a}$	$16.60\pm\sqrt{-5.00}^{a}$
21. % of households owning < 1.50 acres[6]	1066	1736	17591	28842	52.72 ± 0.51	$52.59\pm\sqrt{-12.54}^{a}$	$52.59\pm\sqrt{-13.52}^{a}$
22. % of households owning < 5.00 acres[6]	1066	1736	17591	28842	74.05 ± 0.24	$74.11\pm\ 2.94$	74.12 ± 3.05
23. % of area held by households owning < 1.50 acres[6]	1066	1739	17591	29841	2.82 ± 0.17	$2.78\pm\sqrt{-0.20}^{a}$	$2.77\pm\sqrt{-0.20}^{a}$
24. % of area held by households owning < 5.00 acres[6]	1066	1739	17591	29841	16.31 ± 0.60	$16.17\pm\sqrt{-4.32}^{a}$	$16.17\pm\sqrt{-4.39}^{a}$

[1] Based on Central sub-samples I and II, National Sample Survey : Number 10 (1958a) p.61.

[2] Based on Central sub-samples I and II, National Sample Survey : Number 10 (1958a) p. 117.

[3] Based on sub-samples I and II, National Sample Survey : Number 13 (1958b) p. 57, Table 1.

[4] Based on sub-samples I and II, National Sample Survey : Number 13 (1958b) p. 57, Table 2.

[5] Based on Central sub-sample I and combined Central sub-samples II to IV, National Sample Survey : Number 36 (1961) pp. 163 and 177.

[6] Based on combined State sub-samples I to III and combined State sub-samples IV to VIII, National Sample Survey : Number 36 (1961) pp. 163 and 177.

[a] Negative values of 's^2' are shown under $\sqrt{\ }$ sign.

4. Analysis

We have pooled the estimates from pairs of interpenetrating sub-samples by using (1) equal weights, (2) weights in proportion to sample villages/blocks[1] and (3) weights in proportion to sample households.[2] The estimates together with their standard errors (as estimated from the sample) are given in the Table.

Items given in serial numbers 1 to 16 of the Table indicate that when the sub-samples are of nearly equal size any system of unequal weighting is not likely to improve significantly the precision of the pooled estimate compared to the simple average.

Items given in serial numbers 17 to 24 of the Table are based on sub-samples of widely varying sizes. Since, for the sampling designs considered, the variances of sub-sample estimates may be taken to be proportional to the number of villages (blocks) included in them, it will be seen from (2.3) that the pooled estimate obtained by using the numbers of sample villages (blocks) as weights is the optimum one in the sense that it has minimum variability. Defining efficiency of an estimate as the inverse of its standard error, the percentage loss in efficiency in taking the unweighted average instead of utilizing the optimum weights, can be measured by

Percentage loss in efficiency

$$= 100\{\text{efficiency of optimum estimate} - \text{efficiency of simple average}\}/\{\text{efficiency of optimum estimate}\}$$

$$= 100\{1-(\text{standard error of the estimate with the numbers of villages in sub-samples as weights})/(\text{standard error of unweighted average})\}$$

$$= 100\{1-\sqrt{4n_1n_2}/(n_1+n_2)\}, \qquad \ldots \quad (4.1)$$

when there are only two sub-samples based on n_1 and n_2 villages, respectively . This expression shows that, even when there are large differences in sub-sample sizes, the loss in efficiency due to utilization of the unweighted average is not likely to be significant. For instance, if one sub-sample is twice the size of the other, the loss in efficiency in using the simple average is less than 6%.

As seen from the Table, when the weights are unequal, 's^2' given by (2.4) takes negative values also, introducing, thereby, methodological complications in the estimation of standard error. Further, the estimate of standard error, derived from (2.4), of the (unequally) weighted average appears to be subject to large sampling fluctuations.

5. Conclusions

On the basis of this empirical study we may draw the following broad conclusions. When an interpenetrating sample is designed to have sub-samples of considerably different 'sizes', adoption of weights in proportion to the designed 'sizes' of the sub-samples for pooling together sub-sample estimates, would improve the efficiency of the pooled estimate, though not significantly. The unbiassed estimate of the sampling variance given by (2.4) will, however, be subject to large sampling fluctuations and may assume negative values also, leading to methodological complications in estimating the standard error. In view of these considerations, even when there are large departures (whether deliberate or accidental) from equality of sub-sample sizes in an interpenetrating sample, it would be preferable to use the simple average of the sub-sample estimates for the following reasons :

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[1] It is not strictly valid to use this system of weights in the model as the weights cease to be 'constant' and become stochastic variables. For instance, if in a replication of the survey we find 352 villages in sub-Sample I and 354 villages in sub-sample II we would be using different weights for combining items given in serial numbers 1 to 8 of Table 1.

[2] A remark similar to that made above applies in this case also.

(a) unbiassed estimates of the character and its standard error are easy to compute;

(b) the weights utilized are 'constant' and not 'stochastic' and, therefore, capable of rigorous theoretical treatment;*

(c) loss in efficiency due to utilization of unweighted average is not likely to be significant; and

(d) the estimate of the sampling variance is always positive and does not give rise to any methodological complications in estimating standard error.

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*See also footnote 1, Section 4.

COIN ANALYSIS
ON PUNCHED CARD MACHINE TYPE IBM 101

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SUMMARY. A method of coin analysis on Electronic Statistical Machine Type IBM 101 is described in this paper. The method is faster and more economic than other punched card methods.

1. Introduction

Any transaction in cash involves notes and coins of various denominations. A money disbursing centre that makes a large number of individual payments is therefore interested not only in knowing the total amount of money to be disbursed, but also the number of notes and coins in which this amount should be available, so that all the individual payments can be made directly. This breakdown of the total amount of money into the appropriate number of notes and coins of various denominations is known as Coin Analysis. A lot of time and unnecessary trouble to both the money disbursing authorities and the payees at the time of payment can be saved if coin analysis of the amount is available.

2. The coin analysis table

Consider a 6 digit amount where the last two digits are allotted for the naye paise part. Thousandth and hundredth position of the rupee part gives the number of 100-rupee notes involved in the amount and the number of 10 rupee notes involved is decided by the tenth position of the rupee part.

The number of rupee notes of denominations 5, 2 and 1 has to be decided by the unit's position of the rupee field. If it is greater than or equal to 5, it means that the number of 5-rupee notes involved is one. Similarly the number of 2-rupee notes involved is one if the amount is 2,3,7 or 8 whereas the number will be two if the amount is 4 or 9. It is quite clear that one 1-rupee note is involved in the amounts 1, 3, 6 or 8. Naye paise also can be broken down in coins of 50, 25, 10, 5, 2 and 1 in a similar fashion. This breakdown of amount in denominations of notes and coins can be shown neatly in the following tabular form.

Let x denote the unit's position of the rupee part; y, the ten's position of the naye paise part and z, the unit's position of the naye paise part. The number of notes and coins required for any payment upto Rs. 9.99 is determined by the following rules :

COIN ANALYSIS TABLE

amount	number involved	condition	
notes			
Rs. 5	1	$x \geqslant 5$	(1)
Rs. 2	1	$x = 2, 3, 7$ or 8	(2)
	2	$x = 4$ or 9	(3)
Re. 1	1	$x = 1, 3, 6$ or 8	(4)
coins			
50 nP	1	$y \geqslant 5$	(5)
25 nP	1	$y = 2$ or 7 with $z \geqslant 5$	(6)
		$y = 3, 4, 8$ or 9	(7)
10 nP	1	$y = 1$ or 6	(8)
		$y = 3$ or 8 with $z \geqslant 5$	(9)
		$y = 4$ or 9 with $z \leqslant 4$	(10)
	2	$y = 2$ or 7 with $z \leqslant 4$	(11)
		$y = 4$ or 9 with $z \geqslant 5$	(12)
5 nP	1	$y = 0, 1, 5$ or 6 with $z \geqslant 5$	(13)
		$y = 3, 4, 8$ or 9 with $z \leqslant 4$	(14)
2 nP	1	$z = 2, 3, 7$ or 8	(15)
	2	$z = 4$ or 9	(16)
1 nP	1	$z = 1, 3, 6$ or 8	(17)

To every condition that is satisfied by the amount, we have to take the corresponding denominations of notes or coins in the required number's. The following example will explain this clearly.

Consider the amount Rs. 1439.93. Evidently the number of 100-rupee notes involved in the amount is 14 whereas that of 10-rupee notes is 3. Here, $x = 9$; $y = 9$; $z = 3$.

Now, $x = 9$ satisfies the condition $x \geqslant 5$. Clearly one 5 rupee-note is involved. Moreover it satisfies the condition $x = 4$ or 9 also. Hence two 2-rupee notes also are involved in the amount. Coming to the naye paise part, we see that $y = 9$ $z = 3$ satisfy the conditions

$y \geqslant 5$.

$y = 3, 4, 8$ or 9

$y = 4$ or 9 with $z \leqslant 4$

$y = 3, 4, 8$ or 9 with $z \leqslant 4$

$z = 2, 3, 7$ or 8 and

$z = 1, 3, 6$ or 8

Referring to the coin analysis table we find that 93 naye paise involves one 50np, one 25np, one 10np, one 5np, one 2np and one 1np coins. Thus for any amount we can find out the required number of notes and coins.

The principle explained above is the basis on which we have to instruct the computing machines for coin analysis.

When the number of individual payments is large it will be a laborious process to do coin analysis manually. Here the punched card system provides a swift and reliable method which saves a lot of time and lengthy work and gives the required information in neat tabulated forms.

3. Traditional methods of coin analysis on punched card machines

We have for each payment to be made a card on which the amount of payment and other relevant details are punched. This punched card is passed through the machines at various stages of processing.

Three methods are generally used for coin analysis. They are

Method 1 : Using Sorter, Gang Punch and Tabulator

Method 2 : Using Calculating punch and Tabulator

Method 3 : Using Tabulator only

In the first method, for each amount punched in the unit's position of the rupee field a master card is prepared punching the appropriate combination of the number of 5, 2 and 1 rupee notes involved in the amount. Evidently 9 master cards are to be prepared, one for each of the amount 1 to 9. Similarly 99 master cards one for each of the naye paise 1 to 99 also are to be prepared. Payment cards are sorted on unit's position of the rupee field and the corresponding master card is filed before each group. Using Gang Punch, the note combination is gang punched from the master card on the following group. Similar operation is done for the naye paise field also. After separating out the master cards, payment cards are tabulated on a tabulator to get the final coin analysis.

In the second method, for every card, proper combination of notes and coins is calculated by making use of the principle of the successive division on a Calculating Punch. These calculated cards can be tabulated as explained before.

In the third method, a tabulator is used. One counter is reserved for each type of note or coin and a selector is actuated for every condition mentioned in the coin analysis table. Then a '1' or '2' as is required is added to counters selectively and tabulated at every control level.

4. USE OF IBM ELECTRONIC STATISTICAL MACHINE TYPE 101

A novel method of doing coin analysis on the IBM Electronic Statistical Machine has been devised by the Data Processing Unit of the Research and Training School (ISI).

The ESM (IBM 101) is in effect a special selective counting sorter which can do selective counting with or without changing the order of the cards and print the result.

It has got 60 unit counters each of 4 positions. In each card cycle, a unit counter can add the digit '1' when instructed to do so. For adding the digit 1 in a unit counter we have to make use of a count impulse which is available at the Counter hubs. Each Count mechanism has got one "To" hub and one "Return" hub. A count impulse taken from "Count to" hub is wired to the "In" hub of a unit counter with or without filtering through (recode) selectors and is returned to the corresponding "Count Return" hub by wiring it (i.e. "Return" hub) to the "out" hub of the unit counter. Whenever this count impulse circuit is complete (i.e. "Count To" impulse returns to the "Count Return") the corresponding unit counter through which it passes adds the digit one.

A Recode Selector which is generally used to select a count or sort impulse has got two pairs of pick up hubs and 4 positions arranged vertically on the control panel. Each position has got a common hub, a normal hub and a transfer hub (The upper two positions have a pair of transfer hubs) and the connection of a common hub to the corresponding normal or transfer hub is determined by the impulses available at its recode pick up hubs. Whenever both the pick up hubs get impulses simultaneously that recode selector will be picked up for the following cycle and the common will be connected to the transfer throughout that cycle. When the pick up impulses are not like impulses (i.e. not simultaneous impulses) that recode selector will not be picked up in which case the connection will be between common and normal points. Hence a recode selector can be used to control the machine functions according to some pre-determined conditions. There are 60 such recode selectors equipped in the Electronic Statistical Machine.

There are 14 digit emitters in the ESM each of which serves the purpose of getting the impulses 9 through 12 mechanically.

To count the number of notes and coins involved in any payment we have to make use of recode selectors, unit counters and digit emitters.

Since a unit counter add only unity, whenever we have to add 2, two unit counters are to be used each adding unity, and the corresponding print fields have to be added manually on the tabulation sheet to get the required total. Allocation of unit counters corresponding to the conditions given in the Coin Analysis table is done as shown below :

amount	number involved	condition		unit counters allocated
notes				
Rs. 5	1	$x \geqslant 5$	(1)	2
Rs. 2	1	$x = 2, 3, 7$ or 8	(2)	3
	2	$x = 4$ or 9	(3)	3 & 4
Re. 1	1	$x = 1, 3, 6$ or 8	(4)	5
coins				
50 nP	1	$y \geqslant 5$	(5)	6
25 nP	1	$y = 2$ or 7 with $z \geqslant 5$	(6)	7
		$y = 3, 4, 8$ or 9	(7)	
10 nP	1	$y = 1$ or 6	(8)	8
		$y = 3$ or 8 with $z \geqslant 5$	(9)	
		$y = 4$ or 9 with $z \leqslant 4$	(10)	
	2	$y = 2$ or 7 with $z \leqslant 4$	(11)	8 & 9
		$y = 4$ or 9 with $z \geqslant 5$	(12)	
5 nP	1	$y = 0, 1, 5$ or 6 with $z \geqslant 5$	(13)	10
		$y = 3, 4, 8$ or 9 with $z \leqslant 4$	(14)	
2 nP	1	$z = 2, 3, 7$ or 8	(15)	11
	2	$z = 4$ or 9	(16)	12
1 nP	1	$z = 1, 3, 6$ or 8	(17)	13

Unit counter 1 is used for counting the total number of cards.

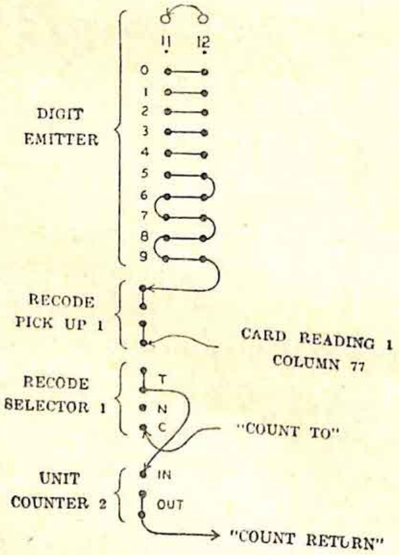
For each classification we can pick up a recode selector by giving digit emitter impulse and the first card reading impulse to its upper and lower pick up hubs corresponding to that classification. From the coin analysis table it is clear that one recode selector is required for each of the conditions 1, 2, 3, 4, 5, 7, 8, 15, 16 and 17 whereas the conditions 6, 9 ,10, 11, 12, 13 and 14 require two recode selectors each. Therefore on the whole 24 recode selectors have to be used.

Since there are 4 recode selector positions corresponding to a pair of recode pick up hubs of every recode selector we can reduce the number of recode selectors. Further economy in the use of recode selectors is possible by appropriately grouping them.

Suppose the selectors are picked up as shown below :—

condition	recode selector number
$x \geqslant 5$	1
$x = 2, 3, 4, 7, 8$ or 9	2
$x = 4$ or 9	3
$x = 1, 3, 6,$ or 8	4
$y \geqslant 5$	5
$y = 2$ or 7	6
$y = 3, 4, 8$ or 9	7
$y = 1, 4, 6$ or 9	8
$y = 3$ or 8	9
$y = 4$ or 9	10
$y = 0, 1, 5$ or 6	11
$z = 2, 3, 4, 7, 8$ or 9	12
$z = 4$ or 9	13
$z = 1, 3, 6$ or 8	14
$z \geqslant 5$	15

To pick up the selector number 1, we will give the digit impulses (5-9) from a digit emitter to one of the pick up hubs of the recode selector 1 and card column x, i.e.



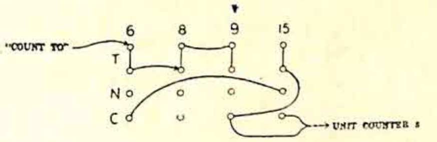
unit's position o rupee field to the other pick up hub. Therefore whenever x is any-one of the digits 5, 6, 7, 8 or 9 selector 1 will transfer. A count impulse wired to the C hub of the recode selector 1 can be taken out of the T (transfer) hub whenever $x \geqslant 5$. This filtered count impulse is added in say-unit counter 2 to add unity. After passing all the payment cards in the machine this unit counter will give the number of 5-rupee notes required for the payment. Following wiring diagram illustrates the counting of the number of 5-rupee notes. Let the payment be punched on card columns 74-79. Hence X, y and z corresponds to the card columns 77, 78 and 79 respectively.

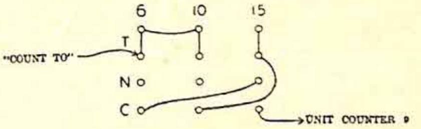
Similarly through the C and T hub of the recode selector 2 which transfers when $x = (2-4)$ and $(7-9)$ corresponding to the conditions (2) and (3) a count impulse is added in the unit counter 3. Following the same principle using selector 3, 4th unit counter gives the number of additional 2-rupee notes required. Then adding manually the printed columns in the tabulated sheet corresponding to the unit counters 3 and 4, we get the total number of 2-rupee notes involved in the coin analysis. Counting of 1-rupee notes can be similarly done using 4th recode selector and 5th unit counter.

Counting of naye paise coins also is done using the same principle as explained before. As an example, consider the case of 10 naye paise coin. Here we have to use 4 recode selectors to select the y impulse (card reading 1, column 78) and another recode selector to select the z impulse (card reading 1, column 79). Selectors 6, 8, 9, 10 and 15 picked up in the following manner :

6	8	9	10	15
$y = 2$ or 7	$y=1,4,6$ or 9	$y=3$ or 8	$y = 4$ or 9	$z \geqslant 5$

Then the schematic diagram to get the count of 10nP coins will be as shown :





By adding the figures corresponding to the unit counters 8 and 9, we get the count of 10nP coins involved in the payment.

Instead of filtering the "count to" impulse through all the 4 selectors 6, 8, 9 and 15 we can filter a "12" impulse emitted from a digit emitter in the same way and this fiitered impulse can be used to pick up a new recode selector by connecting it to its both pick up hubs. This new recode selector will transfer only if any one of the required conditions 8, 9, 10, 11 and 12 is satisfied. Now it is very easy to filter a count impulse, through this single new recode selector, before being sent to the unit counter 8. (Numerical field of the card will decide the condition of the selectors. Digit emitter impulse "12" will be emitted only after the complete reading of numerical field as well as 0, and $x =$ zones. Hence its use here).

If we want the coin analysis for every group, we have to file 9 master cards at the end of every group which by appropriate panel wirint causes the machine to print after every group. Using a GI counter we get group indication also.

Though the speed of the machine is 450 cards per minute the operational speed is about 250-300 cards per minute. We could do the coin analysis of the payroll of about 1250 workers of Indian Statistical Institute belonging to about 35 sections in about 20 minutes.

Coin analysis in ESM is superior to other methods in many ways. In the sorter, gang punch and Tabulator method cards are to be passed thrice in sorter, (one run for sorting on units' position of rupee field and two runs for naye paise field) twice in gang punch (one for gang punching rupee denominations and other for naye paise denominations) and once in Tabulator. That is it requires 6 runs to get the final coin analysis. Calculating Punch and Tabulator method requires two runs. But Electronic Statistical machine gives the coin analysis in a single run. Compared to the speed of Calculating Punch (about 50 cards per minute) and of Tabulator (about 150 cards per minute), speed of ESM (about 450 cards per minute) is far greater. Moreover the sorting order of the payment cards will not be disturbed by passing them in ESM. Hence ESM is best suited for coin analysis.

ACKNOWLEDGEMENT

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TECHNICAL PAPER ON SAMPLE DESIGNS OF WORKING CLASS AND MIDDLE CLASS FAMILY LIVING SURVEYS (1958-59)

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PART 1. INTRODUCTION

1. Historical note

1.1. The existing series of consumer price index numbers* in India are compiled by different agencies in different areas. They originated from specific needs at different points of time in those areas and there is considerable lack of uniformity in the concepts adopted, the methods used for collection of data and the methods of construction of these index numbers. Many of them have a pre-war base and consequently do not reflect the present living conditions of the population classes they are meant for. Their methods of construction and maintenance, particularly those of the older series, leave much to be desired in view of the recent developments in the techniques of statistical surveys.

1.2. Consumer price index numbers for the Working Class are at present being maintained at more than 50 centres all over India, by the different State Governments and the Labour Bureau (which builds up a composite all-India Working Class index number also by using the centrewise index numbers). In some cases, two different series are being maintained for the same centre by two agencies. The weights

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*The consumer price index number for a given class of people is an index built to indicate the change over a certain period of time in the price structure of items consumed by the class. Usually, it is computed by finding the weighted average of the ratios of the prices (price-relatives) of the different items commonly consumed by the class at the two points of time between which the change is to be measured. The weights used are the respective proportions of total expenditure in an average family of the class on the corresponding items of consumption as observed at the original time point (base period). Symbolically, the index at a point of time 't' as compared to the base period '0' is given by I_{t0}.

$$I_{t0} = \sum_{i=0}^{N} W_{i0} \times r_{it0}$$

where $i = 1, 2, \ldots, N$ is over the different items of consumption, r_{it0} = ratio of the price of item i at time point 't' to that at time point '0' and W_{i0} is the proportion of expenditure in the average family on item i at time point 0.

for these series are based on family budget enquiries conducted at these centres at periods varying between 1927 and 1952.

1.3. Very little has been done as regards similar enquiries for the middle class. In 1945-46, the Economic Adviser to the Government of India undertook an enquiry into the budgets of families of Central Government employees. Later, similar surveys were undertaken by the Reserve Bank of India in Bombay, the Gujerat Chamber of Commerce in Ahmedabad and the West Bengal State Statistical Bureau in some cities and towns of West Bengal.

2. ORIGIN

2.1. The different workers' and employers' organisations, the Central Pay Commission and other such bodies who use these index numbers felt that fresh family budget enquiries should be conducted on a uniform basis all over India. In response to the growing demand for a new set of index numbers the Second Joint Conference of Central and State Statisticians held in October 1953, recommended that fresh budget enquiries should be carried out on a uniform basis in all the States during 1955-56. A project for conducting fresh family budget enquiries among working classes at important industrial centres was included in the Second Five Year Plan. Some of the State Governments were also very keen on conducting these enquiries so as to enable them to revise the existing index numbers. For various reasons, however, the project could not be taken up in 1955-56.

2.2. After consultations with various authorities, the Government of India undertook the scheme for conducting the Working Class and Middle Class Family Living Surveys in 1958-59. The following is a report on the plan of the surveys with emphasis on the technical aspects of the sample designs adopted.

3. PLANNING THE SURVEYS

3.1. In pursuance of the recommendations of the Central and State Statisticians Conference and the Planning Commission, the Central Statistical Organisation (CSO) convened a Working Group in February 1954, under the Chairmanship of Professor P. C. Mahalanobis, for discussing the surveys. In May 1954, the Ministry of Labour, in concurrence with the Committee of Economic Secretaries converted this Working Group, with suitable additions of representatives from other ministries, into a Technical Advisory Committee((TAC) to advise on the standardisation of Cost of Living Index Numbers. Professor P. C. Mahalanobis, was the Chairman of this Committee which consisted of representatives from the Ministries of Labour, Food and Agriculture, and Finance, the Planning Commission, the National Sample Survey

(NSS) Directorate, the CSO, the Indian Statistical Institute (ISI) and the Reserve Bank of India. This Committee was set up to guide the Government in the planning and conduct of family budget enquiries, analysis of data collected and final compilation of all-India Cost of Living Index Numbers.

3.2. At its first meeting in February 1954, the TAC (at that time the Working Group) recommended that fresh family budget enquiries should be conducted on uniform lines all over India for the urban working classes, urban middle classes, agricultural labour classes and cultivators. At its second meeting in September 1956, when the division of responsibilities for conducting these surveys was worked out, the TAC recommended that a Working Group on family living surveys constituted by representatives of the CSO, the Labour Bureau (LB), the NSS and the ISI be set up to study and decide the technical details of the proposed working class and middle class surveys and report to the TAC. Accordingly, such a Working Group was constituted and started functioning in March 1957.

3.3. This Working Group had 9 meetings in all wherein it worked out the details relating to the list of centres, definitions and concepts, sampling scheme, price collection scheme, and schedules to be used.

4. ORGANISATIONAL SET-UP

4.1. The Working Class Family Living Survey was sponsored by the LB and the Middle Class Family Living Survey by the CSO. These agencies were mainly responsible for the over-all implementation of the respective enquiries, general supervision of their progress, preparation and printing of reports and construction and maintenance of the corresponding consumer price index numbers. The task of compiling the middle class consumer price index numbers has since been transferred from the CSO to the LB.

4.2. It has already been mentioned that the Working Group set up by the TAC was entrusted with the job of deciding the technical details of the survey. In conformity with the broad decisions arrived at by this group, the ISI finalised the sampling design and the schedules to be canvassed after conducting the necessary preliminary enquiries.

4.3. The agencies for the field work for the family living surveys were the NSS and the ISI field branch (the latter in West Bengal and Bombay city only). The ISI was responsible for processing and tabulating all the data collected, except for Schedule B (on the conditions of living) of the Working Class which was to be processed by the LB.

4.4. As regards price quotations for the Working Class Survey, the LB used its price agency for collection of prices and processed the data itself, whereas for the Middle Class Survey, the NSS field staff collected the prices and the data was processed at the LB.

5. SCOPE OF THE SURVEYS

5.1. The recommendations of the ILO Working Group of Experts on Family Living Studies were considered in planning these surveys. The object of these surveys was two-fold.

(i) To estimate the weighting diagrams for the Working Class and Middle Class in different important centres all over India. These were to be based on up-to-date consumption patterns, and would be used for compiling consumer price index numbers for these classes in each centre. (It was also envisaged that the centre-wise consumer price index numbers so compiled would be utilised in the compilation of a representative composite series of all-India consumer price index numbers for the Working Class and Middle Class separately).

(ii) To collect data for a general study of the living conditions of these classes in the different centres.

5.2. For the first purpose, information on all the different types of receipts and expenditure by the sample family were collected in Schedule A. For the second purpose, Schedule B was used. This schedule covered various aspects of the family such as health, employment, housing conditions, satisfaction of social, cultural and educational wants etc.

6. PERIOD OF THE SURVEYS

6.1. Barring a few exceptions each of the surveys was conducted for a period of one full year in the allotted centres. The period for the Middle Class Surveys was July 1958 - June 1959, and for the Working Class Surveys it was August 1958-July 1959 in each centre. The sample size at any centre was spread evenly over twelve months, to eliminate seasonal variations.

PART 2. WORKING CLASS FAMILY LIVING SURVEY

1. GENERAL

1.1. As stated in paragraph 1.5 of Part 1, it was decided to collect data on the consumer expenditure and general level of living of the working class in certain specified centres distributed all over India. These centres were towns or cities which were important for their working class populations. The survey was planned separately in each centre, taking into consideration the local conditions obtained there and a suitably selected sample of working class families was contacted for collection of data.

2. CONCEPTS

2.1. For the purposes of this survey, the Working Class was defined broadly to include those who did manual work in registered factories, mines or plantations (registered under the Factory, Mine or Plantation Acts of 1948, 1952 and 1951 respectively. Refer Appendix 3 for relevant extracts from the Acts). Information was collected only from working class families in each centre. A working class family was defined as one which derived 50 per cent or more of its income through manual work in a registered factory, mine or plantation in the calendar month preceding the date of initial contact of the family (while listing). It may be noted that only families of factory workers were to be surveyed in a centre which was specified as a factory centre; only families of mine workers in a mining centre and only families of plantation workers in a plantation centre.

3. SELECTION OF CENTRES

3.1. Initially the TAC decided that the survey should be conducted in about 40 important factory, mining and plantation centres representing the industrial areas of India. The numbers of centres that would represent these three industry sectors were first determined in proportion to the all-India employment in the corresponding industry sectors. The number of centres for each sector was distributed to the States in proportion to their employments in that sector. A State which had substantial employment in a particular sector but did not receive any allocation by the above procedure (because its employment in that sector was comparatively low judged at the all-India level), was allocated one centre to represent that sector. The State Governments were then requested to name the allocated number of important centres in each sector in their respective States. Later, after mutual consultations between the Labour Bureau and State Governments some changes were made in the list so as to ensure better representation for different types of industries, mines or plantations and better geographical coverage within each State.

3.2. There were 50 centres in all of which 32 were factory centres, 8 were mining centres and 10 were plantation centres. The complete list of centres is given in Table 1.

TABLE 1. LIST OF CENTRES AND SAMPLE SIZES FOR THE WORKING CLASS FAMILY LIVING SURVEY

srl. no.	state	centre	sampling method adopted	number of investi-gators	number of families for	
					schedule A	schedule B
(1)	(2)	(3)	(4)	(5)	(6)	(7)
		(a) *factory centres*				
1.	Andhra Pradesh	Guntur	T	1	180	60
2.	,,	Hyderabad	P	2	480	120
3.	Assam	Digboi	T	1	240	60
4.	Bihar	Jamshedpur	P	4	720	240
5.	,,	Monghyr-Jamalpur	P	2	480	120
6.	Bombay (now Gujerat)	Ahmedabad	T	4	720	240
7.	,, ,,	Bhavnagar	P	1	240	60
8.	,, (now Maharashtra)	Bombay	T	8	1440	480
9.	,, ,,	Nagpur	P	3	720	180
10.	,, ,,	Sholapur	T	3	540	180
11.	Jammu and Kashmir	Srinagar	P	2	480	120
12.	Kerala	Alleppey	T	2	360	120
13.	,,	Alwaye	P	1	240	60
14.	Madhya Pradesh	Bhopal	P	1	240	60
15.	,,	Gwalior	T	2	360	120
16.	,,	Indore	P	2	480	120
17.	Madras	Coimbatore	P	3	720	180
18.	,,	Madras	P	4	960	240
19.	,,	Madurai	T	2	360	120
20.	Mysore	Bangalore	T	4	720	240
21.	Orissa	Sambalpur	P	1	240	60
22.	Punjab	Amritsar	T	3	540	180
23.	,,	Jamunanagar	P	1	240	60
24.	Rajasthan	Ajmer	T	2	360	120
25.	,,	Jaipur	P	1	240	60
26.	Uttar Pradesh	Banaras	P	1	240	60
27.	,,	Kanpur	T	4	720	240
28.	,,	Saharanpur	T	2	360	120
29.	West Bengal	Asansol	P	3	720	180
30.	,,	Calcutta	T	4	720	240
31.	,,	Howrah	P	5	1200	300
32.	Delhi	Delhi	T	4	720	240
	total		—	83	16980	4980

T : tenement sampling method P : payroll sampling method

TABLE 1. LIST OF CENTRES AND SAMPLE SIZES FOR THE WORKING CLASS FAMILY LIVING SURVEY (*contd.*)

srl. no.	state	centre	sampling method adopted	number of investi-gators	number of families for schedule A	number of families for schedule B
(1)	(2)	(3)	(4)	(5)	(6)	(7)
		(b) *mining centres*				
33.	Andhra Pradesh	Gudur	P	1	240	60
34.	Bihar	Jharia	P	4	960	240
35.	,,	Kodarma	P	1	240	60
36.	,,	Noamundi	P	1	240	60
37.	Madhya Pradesh	Balaghat	P	1	240	60
38.	Mysore	Kolar G. F.	T	1	180	60
39.	Orissa	Barbil	P	1	240	60
40.	West Bengal	Raniganj	P	2	480	120
	total			12	2820	720
		(c) *plantation centres*				
41.	Assam	Doom Dooma	P	2	480	120
42.	,,	Labac	P	1	240	60
43.	,,	Mariani	P	1	240	60
44.	,,	Rangapara	P	2	480	120
45.	Kerala	Mundakkayam	P	1	240	60
46.	Madras	Coonoor	P	1	240	60
47.	Mysore	Ammathi	P	1	240	60
48.	,,	Chikmagalur	P	2	480	120
49.	West Bengal	Darjeeling	P	2	480	120
50.	,,	Jalpaiguri	P	2	480	120
	total			15	3600	900
	grand total			110	23400	6600

T : tenement sampling method   P : payroll sampling method

4. FIXATION OF SAMPLE SIZE FOR THE CENTRES

4.1. It was necessary to determine the sample size required in any centre (in terms of number of families to be surveyed) which would provide a sufficiently precise estimate of the consumer price index number for that centre. Evidently the precision of the consumer price index number depends very much on the price relatives used in building it up ; in fact, more on the magnitude and variance of the price relatives and their covariance with the weights than on the variance of the weights used. The TAC posed the problem thus—if the price relatives remained constant, what sample size would be required to provide estimates of consumer price index numbers with a margin of error not exceeding 3 or 4 per cent. The Working Group later decided that the maximum error permissible should be 2 per cent and not 4 per cent since the index was an important economic indicator. The error of the index number would under these restrictions depend on the variation in the relative magnitudes of the price relatives used, and the sampling variation in the estimated weights. A study was made using the weights obtained from the Jagaddal Labour Enquiry conducted by the ISI in 1941 and two sets of price relatives, one for 1942 and one for 1945 with 1941 as base. Studies were also made on the basis of 9th round NSS data for Bombay, Ahmedabad and Madras to have an idea of the error of the food index alone for different sets of price relatives. These led to the conclusion that a sample of 300 to 1000 families per centre (depending on the type and size of centre), would possibly satisfy the requirements for precision set down for the consumer price index number, and for obtaining sufficiently precise estimates of the weights for the major groups of items. In centres where there is considerable variation in the consumption patterns of the working class (because of the large number and different types of labourers in them), the sample size would have to be considerably large, and in small centres particularly in mining and plantation centres where there is less variation in the consumption patterns of the working class, a smaller sample size would suffice.

4.2. Another important consideration in fixing the final sample size in any centre was the work-load manageable by an investigator. From NSS experience it was decided that a two-stage sampling design where blocks of houses (in a tenement* sampling centre) or groups of establishments (in a payroll* sampling centre) were selected in the first stage, and working class families or workers in the establishmets were selected in the second stage would be suitable for this survey. It was necessary that the number of blocks or establishments thus covered was fairly large to get representation of different types of the working class living in different areas. After field testing of the time taken for listing blocks (of the size of 1951 census enumerator blocks), collecting payrolls and canvassing the proposed schedules, it was found that an investigator could list about 3 blocks and survey about 20 families per month in a tenement centre and collect payrolls of 3 to 4 establishments and survey about 25 families in a payroll centre (larger in the latter case, because of the lesser time taken for collecting payrolls). Thus the minimum sample size was fixed at 240 families for a tenement sampling centre and 300 for a payroll sampling centre. Of this one fourth and one fifth of the sample size was set apart for the study on conditions of living (Schedule B) in tenement sampling and payroll sampling centres respectively. The suggestion that both the schedules could be canvassed in this fraction of the sample was dropped because of the length of the schedules and the consequent fatigue that such a scheme would cause both to the informant and the investigator. The effective sample size for Schedule A, i.e., for estimating weights for the index number therefore had to be 180 or its multiple in a tenement sampling centre and 240 or its multiple in a payroll sampling centre.

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*In tenement sampling, a sample of working class families is drawn from a frame of residential blocks and families, whereas in payroll sampling a sample of workers is drawn from the payrolls of the factories, mines or plantations in the centre and the families to which they belong are contacted for obtaining the required information. See paragraphs 6.1 to 6.3 for further details.

4.3. With the budget limitation of about 100 investigators that could be employed for this survey, the sample size for each centre was fixed as a multiple of either of the sizes arrived at above depending on the type of sampling method to be adopted. This was done after considering the size (measured by the labour force employed in that centre), importance of the centre and expected variation in the consumption pattern of working class living in the centre.

4.4. One important recommendation of the TAC was that provision should be made for having at least two independent sub-samples in each centre. Since it was desirable to maintain this independence at the stage of collection of data also by allotting one sub-sample to each investigator this meant a minimum sample size of 360 for a tenement sampling centre and 480 for a payroll centre for estimating weights.

4.5. With the budget limitations imposed, however, it was found that this could not be achieved without substantial decrease in the sample size for the larger centres. Further, a sample size of 360 or 480 was not required in the very small centres. In 20 of the smallest centres, therefore, the sample size was kept at 180, if it was a tenement centre and 240 if it was a payroll centre. In each of them two independent sub-samples of 90 or 120 families each were allotted to two six-monthly periods, each period consisting of six alternate months. In these centres, independence at the investigation stage was achieved by pairing two nearby centres and interchanging the investigators between them, every alternate month. [Due to operational difficulties in interchanging investigators in Assam, the sub-sample restriction was relaxed in Labac, Mariani and Digboi after a few months' work and one investigator worked in each of these centres thereafter.]

The final allocation decided for the centres is given in Table 1.

5. PRELIMINARY SURVEY

5.1. The different conditions prevailing in the different centres required a study of these local conditions for efficient centrewise planning of the details of the survey. To this end, a preliminary survey was taken up in each centre. The main purposes of this survey were (i) to fix the boundaries of the centre, (ii) to decide on the most suitable sampling method for the centre, (iii) to prepare a suitable sampling frame and (iv) to test the schedules framed for the survey and study the operational difficulties that would arise in the centre during the main survey. This survey was conducted in the period December 1958-February 1959 and was of one to two months' duration in any one centre. The field officer in charge of this preliminary survey consulted the labour, trade union, municipal and other knowledgeable authorities of each centre and collected the required information in the questionnaires and schedules drafted for this purpose. A copy each of the instructions for the preliminary survey, the questionnaires and schedule used are given in Appendix 2.

6. CHOICE BETWEEN SAMPLING METHODS

6.1. The Working Class in any centre could be contacted by two different methods. The 'tenement sampling method' consists in approaching them through the tenements which they inhabit or their places of residence. This is the method of sampling adopted in the NSS socio-economic surveys. For practical convenience, a number of 'blocks' or tenements are sampled in each town, and within these blocks, the families living in them are listed and sampled. The other method, called the 'payroll sampling method', is to approach them through their places of work. A number of establishments employing the working class are sampled and workers are sampled from the payrolls of these establishments and their families are contacted. The suitability of either of these methods for a centre depended on the local conditions. If the working class were concentrated in some areas of the centre, tenement sampling would be operationally effective, whereas if they were dispersed over a large area, the payroll method would be more effective.

6.2. For the tenement sampling method, the NSS had already with it the list of blocks (based on the 1951 census blocks) for every town/city, which was used for the normal NSS surveys and could be used as the frame for the first stage sampling. In some centres these lists were outdated and the blocks were difficult to identify or had to be subdivided because they were too large. For the payroll sampling method, the latest list of establishments for the centre had to be collected from the Inspector of Factories, Mines or Plantations or other connected authorities in the centre. If this method was to be adopted it had to be ensured that the payrolls of the establishments were accessible and complete and that it would be easy to use them as a frame for sampling workers and later for contacting the families of the sampled workers for detailed investigation (the investigation could not possibly be conducted at the place of work).

6.3. During the preliminary survey at each centre the officers of the NSS acquainted themselves with the local conditions in the centre by visiting the working class areas and discussing with the local authorities. The decision as to which sampling method was to be adopted in any centre was based on the reports of these preliminary enquiries. In some large centres, tenement sampling method was abandoned in favour of payroll sampling because the preliminary enquiry for picking out areas of labour concentration etc. would have required prohibitive time. The method of sampling adopted in each centre is shown in Appendix 1. The payroll method was adopted in 17 factory centres and in all the plantation and mining centres except in Kolar Gold Fields where tenement sampling was found to be more practicable. In the remaining centres tenement sampling method was adopted.

7. BOUNDARIES OF CENTRES

7.1. Since each of the centres selected was to represent the Working Class population of the area in which it was situated, it was evident that the municipal or corporation limits of the centre named would not necessarily define the boundaries of the centre for the purposes of this survey. Very often there was a large proportion of workers coming from outside the administrative boundaries of the centre to work in the industrial establishments within it ; or a large number of such establishments were situated outside the administrative limits of the centre and employed labour from that centre. The first task of the NSS officers in charge of the preliminary survey was to consult the local authorities in the centre and arrive at the boundaries of the centre. The boundaries were fixed so that if it was a centre where tenement sampling was to be adopted, a sizeable majority of the working class population of that area resided within these limits and alternatively if it was a centre where payroll sampling was to be adopted, the industrial establishments which employed a sizeable majority of the working class population of that area were situated within the prescribed boundaries. (One restriction imposed was that the geographical size of the centre should not be so big as to be unmanageable in a localized survey of this kind). In the latter case this amounted to defining the centre by a list of factories, mines or plantations which commonly went by the name of the selected centre thereby covering the families of all the workers employed in these establishments. In some cases the Labour Bureau, with its knowledge of the area after consultation with the State Government concerned, defined the boundaries of the centre, and the local authorities were asked to suggest modifications to this. All these suggestions at various levels were pooled to decide upon the final boundaries.

7.2. The boundaries adopted in each centre are given in Appendix 1.

8. TENEMENT SAMPLING METHOD : FRAME COLLECTION

8.1. In a centre where the tenement sampling method was adopted, the boundary fixation (geographical) and collection of the basic frame was done during the preliminary survey. Having fixed the boundaries of the centre, those areas of the centre which could be safely omitted from the survey coverage (because they contained meagre working class populations) were demarcated with the help of the local authorities. In the rest of the area, from which blocks would be sampled, the blocks were classified into two types — those which had working class residing in them in large concentrations and were therefore important for this survey, and those which did not have. This was done by marking out all such well-known important concentrations on a map or determining their boundaries and matching them with the NSS frame of blocks. Sometimes, important wards were picked out, and in these wards and other smaller pockets of working class concentration, the blocks constituting them were classified as important or not according to the proportion of working class population in them. Wherever sufficiently reliable information was available, information was also obtained on the industry-wise and State-wise distribution of the working class in each such concentration. The State to which a person belongs, and sometimes the industry in which he is employed affects his consumption pattern ; this information therefore proved useful in improving the sampling procedure. The actual size of each block, i.e., its population, which would be relevant for controlling the listing time, was obtained either by local enquiry or by using 1951 census figures. This list of blocks was the sampling frame.

8.2. The proforma of the questionnaires and schedule used for the preliminary enquiry will give an idea of the form in which the information described above was collected (refer Appendix 2).

8.3. In a few centres where the 1951 census blocks could not be identified, blocks of the same size as in 1951 census were formed specially for this survey, and used as the sampling frame in the same manner as above.

8.4. *Sampling of blocks.* The number of investigators to be allotted to a centre was obtained by dividing the sample size for Schedule A for a centre by 180 (which was the prescribed workload for an investigator for a year). Because of the workload restrictions it was decided to sample 36 blocks per investigator in any centre, and distribute these over the months of enquiry at the rate of 3 blocks per month. The samples for different investigators were drawn independently. The first stage unit of sampling was a group or cluster of blocks.

8.5. In a centre, if reliable auxiliary information was available and it was observed that there was substantial variation in the types of working class concentration in the different blocks, clusters of 3 blocks each were formed so as to include in a cluster blocks of different concentrations and different types of workers (belonging to different States and different industries). Attempts were also made to equalise the cluster sizes with respect to population. If sufficiently reliable auxiliary information was not obtained on the nature of working class composition in the different blocks, they were grouped into clusters of 3 blocks each thus : while grouping attempts were made to include blocks from different areas of the centre in a cluster so as to ensure some measure of heterogeneity in the cluster and to make each cluster size equal, comprising of about 450 households. In either case a simple systematic sample of 12 such clusters was drawn independently for each sub-sample and allotted to an investigator.

8.6. For operational convenience, if the number of blocks in a centre was too large for forming such clusters before selection, the clusters were formed after selection in the following manner. The blocks were arranged by the criteria for clustering and a systematic sample of 36 blocks was drawn from this list and the selected blocks were then grouped to form 12 clusters of 3 blocks each, the grouping being done in a systematic manner using the same arrangement. In cases where reliable information was also recorded on the expected number of workers or the working class population in each block, this was used as a measure of size for the blocks, and clusters were selected systematically with probability proportional to the total of this size for the blocks constituting them.

8.7. In some cases where a marked difference was noted in the degree of concentration of the working class in different blocks, they were separated into two strata, one containing blocks with a high concentration of the working class and the other containing the remaining blocks. The quota of 3 blocks per month per investigator was distributed in the ratio 2 : 1 or 1 : 2 to these two strata depending on the total strength of the working class population in them. Within each stratum, sampling of the blocks or clusters of blocks (if the allocation was 2 per month) was done utilizing the relevant information available as in those centres where no stratification was adopted.

8.8. *Selection of artificial blocks.* In centres other than those where pps sampling was adopted as described in paragraph 8.6, if it was found that the expected population in a block was very large according to the information collected at the preliminary survey artificial block selection was adopted. In such cases, the number of divisions into which this block was to be divided was specified at the stage of sampling such that each such artificial division had roughly the size of an average block (150 households). Selection of these blocks was systematic with probability proportional to the number of artificial divisions in them. That is, in 8.4 to 8.7 above, these blocks were given as many serial numbers as the number of artificial blocks specified, before systematic selection. On the field, the investigator demarcated the block into the required number of artificial blocks which were clearly identifiable and of roughly equal size and selected one of them at random for the actual survey. In any case, whether artificial block selection was specified or not, if it was found that a sample block was unmanageable in size the investigator decided the number of artificial blocks himself, according to the above criteria (this number could be different from the number specified for a block where that was done already) and proceeded about artificial block division as described above.

8.9. *Random order of visit to blocks.* In the larger cities, it was found after a few months of survey that because of the size of the blocks and the difficulties in contacting the heads of the households, listing took so much time that keeping to the programme of work was impossible. Artificial block division did not appreciably reduce the listing time because forming them in itself was time-consuming. For the remaining months, therefore, the following scheme, designed to cut down the listing time, was adopted. The 3 blocks to be surveyed in a month were given a random order of visit. The investigator listed the blocks in that order. If on completely listing the first block in this order he found that he had listed 450 or more families and had obtained 25 or more working class families among them, he could stop listing and select the families from that block rejecting the blocks not listed. If not, he completely listed the second block also. And if the prescribed quota of families (450 or more listed with 25 or more working class families among them) was obtained in these 2 blocks put together, he stopped listing and selected the families from these 2 blocks rejecting the third block. Of course, the investigator had to list the block with order of visit 3 also, had the first two together not yielded the quota of 450 and 25 families for listing and survey respectively. This procedure helped in reducing the listing time and stabilising the work programme.

8.10. *Allotment of clusters to months.* Each of the 12 clusters sampled for an investigator was assigned to a particular month for enquiry, by a random process.

8.11. *Casualties and substitution of blocks.* As mentioned earlier, since the sampling frame used was usually the 1951 census list of blocks, many difficulties were faced in identifying the sampled blocks. In a few cases when a block could not be identified at all, or was demolished, or could not be listed for security reasons (if it fell within military area) this was intimated to the ISI and a substitute was given or sampling was done from the remaining blocks in the cluster. The substitute was the block next to the casualty block in the sampling frame.

8.12. In a few centres, due to unavoidable practical difficulties such as an investigator resigning and no substitute being appointed immediately to take his place, or due to the excessive time taken in listing (this happened in the beginning of the survey) it was found that some clusters had to be treated as casualties. Wherever feasible, the investigator was allowed to sample the families for that month from the families listed for a cluster surveyed earlier so as to save the listing time and avoid a total casualty for that month.

8.13. *Sampling of families.* The second stage unit for selection was a working class family. Each month, the investigator listed all the families in the cluster allotted to that month by a house-to-house visit and classified them as working class families and others. While listing, information was also collected on the family size, the expenditure class to which it belonged and the state of origin of the head of the family. The two expenditure classes were those with expenditure less than Rs. 60 per month and others. Families belonging to the state of origin of the majority of families in the cluster, were put in one class and the rest formed the other class. This information was used to arrange the working class families in the cluster, first by family size (single member families, and others) and within these classes by expenditure class and within these by the state of origin class. A simple systematic sample of 20 working class families was drawn from this arranged list. Every fourth family in this sample was contacted for filling in Schedule B (level of living) and the remaining were for Schedule A (consumer expenditure). In centres where stratified sampling was adopted, the number of families to be sampled separately from each stratum in any month was determined by allocating 20 between the strata in proportion to the expected size of the working class population in them. Schedule L(w) was used for listing and selecting families. A facsimile copy of this schedule is given in Appendix 4.

8.14. *Substitution of families.* In case a particular family could not be contacted due to various reasons, or refused to give information, (even after trying all the means of persuasion available with the field officers), or was found to be not a working class family at the time of detailed enquiry, it was substituted by the next working class family in the arranged list for that cluster. It may be noted that in case the main earners of a family were employed in manual labour in registered establishments but were on strike or lay-off for a period of not more than 45 days preceding the date of enquiry, that family was treated as a working class family even if 50 per cent or more of its income in the last calendar month was not from manual labour in registered establishments (as is required by the general definition).

8.15. If in a sampled cluster for a particular month the required number of working class families (20) was not available, the deficiency was made up from the sampling frame for the next month's cluster for the same stratum (if any) and sub-sample so as to keep the total sample size unaltered.

9. PAYROLL SAMPLING METHOD : FRAME COLLECTION

9.1. In centres where this method was adopted, the latest available complete list of registered establishments (factories, mines or plantations) in the centre that would serve as the first-stage sampling frame was compiled during the preliminary survey. Information, wherever available, was also obtained on the number of persons employed, the industry and management type, the seasonal nature of work and any other relevant classificatory character applicable to the establishment. To have an idea of the geographical distribution of the estabishments in mining and plantation centres (where travelling facilities were often poor and had to be considered when sampling), a map showing their location was prepared, or the distance and sometimes the direction of each establishment from the headquarters of the centre was obtained. A brief description of the sampling frames used in the different centres is given in Appendix 1.

9.2. *Sampling of establishments.* The establishments were clustered into groups of 2, 3 or 4 depending on their size (number employed) so as to have clusters of roughly equal size. Attempts were made to group within a cluster establishments which were as different as possible with respect to the various relevant auxiliary characters on which information was obtained. In mining and plantation centres, because it was expected that travelling would be difficult, it was ensured as far as possible that a cluster was composed of units which were not very far apart. 12 clusters per sub-sample were sampled systematically with probability proportional to the total size of the clusters, after arranging them in increasing order of size and allotted to an investigator. In cases where the sizes were not available or where it was reported that the sizes recorded were not reliable, the sample of clusters was drawn systematically with equal probability.

9.3. In some centres where the sizes of a few establishments were very large compared to the average size of the others, the large establishments were grouped to form a stratum and the remaining establishments constituted another stratum. Clustering and sampling were done separately within each stratum. The number of factories to be sampled each month from the two strata was decided on the basis of the stratum sizes. Sometimes it happened that there was one very big establishment which employed a substantial majority of the workers in the centre. In that case this establishment was repeated in the sample every month and a cluster of factories was sampled from among the remaining. The sampling within strata was similar to that in centres where there was no stratification. The method of sampling adopted in each centre is given in Appendix 1.

9.4. *Allotment of clusters to months.* The month to which any cluster was allotted for enquiry was decided by a random process as in tenement sampling centres.

9.5. *Substitution of establishments.* If while listing, a sample establishment was found to have been closed down permanently or temporarily for a sufficiently long or indeterminate period, it was substituted by some other establishment in the same stratum (if any) which was similar to it in respect of industry, number employed, etc.

9.6. If a seasonal establishment was allotted for survey in a month outside the season in which it was expected to be working, it was exchanged with a sampled establishment which was expected to be working then. Sometimes such exchanging was done after actually visiting the establishment for enquiry, because the seasonality was known only then.

9.7. If an establishment was inaccessible in the month of enquiry because of a strike or lay-off, it was exchanged with a similar establishment allotted to a month when it was expected to be working.

9.8. *Sampling of workers.* In payroll sampling centres, the ultimate sampling unit, a working class family was approached through the payrolls of the establishments. The payrolls of each sampled establishment was collected, after ensuring that it was complete, without duplications, and up-to-date. Within each establishment any available arrangement by sections, grade, or type of work was retained and from the pooled payrolls of the establishments in a cluster a simple systematic sample of 25 workers was drawn. Of this, a simple random sample of 5 workers was selected for Schedule B (level of living) and the remaining 20 were taken for Schedule A (consumer expenditure). In centres where stratified sampling was adopted, the number of workers to be sampled from a stratum was specified proportional to the size (total number of workers) of the stratum. Selection was, as described above, within each stratum. A facsimile copy of Schedule P in which selection of workers was recorded is given in Appendix 4.

9.9. The families to which the sampled workers belonged were contacted for the actual enquiry. If the same family was to be contacted more than once in the same month for the same schedule because two or more of the workers in it were sampled in that month, the schedule was duplicated as many times as the family was sampled for the purposes of final tabulation.

9.10. *Substitution of families.* As in the case of tenement sampling, substitution by the family of the worker listed next was resorted to when the sampled family could not be contacted or refused to give information, (even after all efforts were made by the field officers) or when the sampled family was not a working class family according to the prescribed definition. If from a sampled cluster for a particular month the required number of working class families (25) was not available, the deficiency was made up from the sampling frame for the next month's cluster for the same stratum (if any) and sub-sample so as to keep the total sample size unaltered.

PART 3. MIDDLE CLASS FAMILY LIVING SURVEY

1. General

1.1. In this survey data on consumer expenditure and level of living were collected from families sampled in some towns and cities distributed all over India which were important for their middle class populations.

2. Concepts

2.1. The middle class was defined as the class comprising those who were gainfully occupied as employees (in both the public and private sectors) doing non-manual work in the non-agricultural sector. This would exclude the working class (as defined for the working class survey), those employed in the agricultural sector and other employers and self-employed persons and would include the principal categories of people to whom a middle class consumer price index number is of interest. Information was collected only from middle class families in each centre. A middle class family was defined as one which derived 50 per cent or more of its income in the calendar month preceding the date of listing of the family from the occupation of one or more of its members as employees doing non-manual work in the non-agricultural sector. No income limits were proposed at the stage of collecting the information—such limits were to be imposed, centrewise, at the stage of tabulating the data so as to exclude the very rich and the very poor who do not actually belong to this class.

3. Selection of centres

3.1. At the first meeting of the TAC it was suggested that the survey would cover the 4 big cities, Delhi, Bombay, Calcutta and Madras and the urban areas in the 6 census zones, to be treated, possibly, as separate strata so that separate consumer price index numbers could be constructed for each of them as well as for all-India. Later, after consultations with the Ministry of Finance it was decided that the survey would be conducted in about 45 different centres distributed over all the States, the centres being chosen in consultation with the State Governments.

3.2. These centres consisted of the State capitals and other large cities and towns which were important business centres or where there was considerable middle class concentration, because the index number for each such individual centre would be required for the adjustment of pay-scales and allowances for Government employees and employees of banking, insurance and other commercial concerns.

TABLE 2. LIST OF CENTRES AND SAMPLE SIZES FOR THE MIDDLE CLASS FAMILY LIVING SURVEY

srl. no.	state	centre	number of investigators	number of families for schedule A	number of families for schedule B
(1)	(2)	(3)	(4)	(5)	(6)
1	Andhra Pradesh	Hyderabad-Secunderabad*	4	720	240
2	,,	Waltair-Vishakapatnam	3	540	180
3	,,	Vijayawada	3	540	180
4	,,	Kurnool	2	360	120
5	Assam	Shillong	2	360	120
6	,,	Gauhati	2	360	120
7	Bihar	Patna	3	540	180
8	,,	Ranchi	3	540	180
9	,,	Muzaffarpur	2	360	120
10	Bombay (now Gujerat)	Ahmedabad*	4	720	240
11	,, ,,	Rajkot	3	540	180
12	,, (now Maharashtra)	Bombay*	8	1440	480
13	,, ,,	Poona	4	720	240
14	,, ,,	Nagpur*	4	720	240
15	Jammu and Kashmir	Srinagar*	2	360	120
16	,,	Jammu	2	360	120
17	Kerala	Trivandrum	3	540	180
18	,,	Kozhikode	3	540	180
19	Madhya Pradesh	Bhopal*	3	540	180
20	,,	Indore*	3	540	180
21	,,	Gwalior*	3	540	180
22	,,	Jabalpur	3	540	180
23	Madras	Madras*	6	1080	360
24	,,	Madurai*	3	540	180
25	,,	Tiruchirapalli	3	540	180
26	Mysore	Bangalore*	4	720	240
27	,,	Mangalore	3	540	180
28	,,	Hubli-Dharwar	3	540	180
29	,,	Gulbarga	2	360	120
30	Orissa	Cuttack-Bhubaneswar	3	540	180
31	,,	Sambalpur*	2	360	120
32	Punjab and Himachal Pradesh	Chandigarh	3	540	180
33	,,	Amritsar*	3	540	180
34	,,	Simla	2	360	120
35	Rajasthan	Jaipur*	3	540	180
36	,,	Jodhpur	3	540	180
37	,,	Ajmer*	3	540	180
38	Uttar Pradesh	Lucknow	4	720	240
39	,,	Kanpur*	4	720	240
40	,,	Allahabad	3	540	180
41	,,	Agra	3	540	180
42	,,	Meerut	3	540	180
43	West Bengal	Calcutta*	8	1440	480
44	,,	Kharagpur	3	540	180
45	Delhi	Delhi-New Delhi*	6	1080	360
	total		149	26,820	8,940

* Selected for the Working Class Family Living Survey also.

Note : Tenement sampling method in all the centres except in stratum 1 of Kharagpur where payroll sampling was adopted.

3.3. Initially, the State capitals were selected and their number was 16. The allotment of the remaining centres to the different States was in proportion to their urban middle class populations (excluding the populations of the capitals). Each State Government named the required number of important centres to fulfil the quota allotted. Minor changes were made later to allow better regional representation within a State. The final list of 45 centres selected is shown in Table 2. It may be noted that 18 of these centres were selected for the Working Class Family Living Survey also.

4. Fixation of sample size

4.1. The requirement, as in the case of the Working Class Survey, was to fix the sample size that would ensure less than 2 per cent error in the consumer price index number for any centre. Again, it was difficult to arrive at such a sample size without knowing the pattern of price relatives. However, after studying the NSS urban data, results of the Faridabad township survey conducted by the ISI and the family budget survey in urban areas conducted by the West Bengal State Statistical Bureau it was felt that a sample of 400 to 500 families would be required in the smaller centres and about 1000 families in the bigger cities. The larger heterogeneity in the consumption pattern and living habits of the middle class within the bigger centres warranted a larger scale of sampling in them as compared to the smaller centres.

4.2. The budget sanction expected for the survey allowed a field-staff of about 150 investigators. It was decided that the easiest and possibly the only way of contacting the middle class families was through tenement sampling. The work-load for an investigator with the type of two-stage design that was considered suitable for this survey involving listing of about 3 blocks per month was put at 20 families per month, or 240 a year. One-fifth of the sample size was set apart for the study on conditions of living.

4.3. The distribution of the total sample size to the different centres was made on a joint consideration of their 1951 census population and expected middle class population as judged from census figures in the relevant occupation classes and NSS estimates wherever available. The allocations were rounded off to multiples of 240. It was found that two investigators to provide two independent sub-samples of 240 families each could be afforded for each of the smaller centres also. The final allocation of sample size to each centre is shown in Table 2.

5. Preliminary enquiry

5.1. A preliminary enquiry was taken up for a few weeks in each centre for the purposes of studying the middle class concentrations in the centre, fixing up the boundaries of the centre and collecting the frame required for sampling.

6. SAMPLING METHOD ADOPTED

6.1. The tenement method of sampling was adopted in each centre because sampling middle class from the payrolls of establishments which employed them would be an inconceiveable task. A block was the first-stage unit and a middle class family was the second-stage unit (refer paragraphs 6.1 and 6.2 of Part 2).

7. BOUNDARIES OF THE CENTRES

7.1. To cover the middle class population in each centre it was decided to go by the municipal or corporation limits of the centre. If well-known middle class colonies had sprung up in the immediate neighbourhood of above mentioned limits they were also included in the centre for the purposes of this survey.

8. FRAME COLLECTION

8.1. The task of frame collection was therefore reduced to that of procuring a complete list of blocks covering the whole area of the centre falling within its boundaries defined as described above. Very often, this frame was the 1951 census list of blocks. For new middle class residential areas which had sprung up after the 1951 census, blocks were formed by the investigator along lines similar to that adopted in the 1951 census, to make the frame complete. In some centres, it was found that the 1951 census lists of blocks was wholly inadequate for this survey because of their obsoleteness, unidentifiability and the large size of blocks. So an entirely new list of blocks was prepared by the NSS Officer, sometimes with the help of the municipal divisions in the centre which were more up-to-date. In Gauhati and Chandigarh this was done after a few months of the survey because the earlier frames were found unsuitable only after the actual survey had started. In these cases, for the remaining months a new sample was drawn from the newly constructed frames.

8.2. No attempt was made to mark out middle class localities in each centre, because picking out localities in which the middle class (as defined for this survey) resided would have been almost impossible. In centres common for the Middle Class and Working Class Surveys, the information on the working class concentrations in different areas was used, as far as possible, to exclude the highly concentrated working class areas from the Middle Class Survey.

8.3. In some other centres also where reliable information was readily available that some areas had very little middle class population in them such areas were excluded from the sampling frame.

9. SAMPLING OF BLOCKS

9.1. In each centre, a simple systematic sample of 36 blocks was selected per sub-sample, the arrangement of the blocks in the frame being kept unaltered. Then the sampled blocks were clustered into 12 clusters of 3 blocks each by grouping 1st, 13th and 25th sampled blocks into one cluster, the 2nd, 14th and 26th sampled blocks into another cluster and so on. This method of clustering was adopted to ensure some measure of geographical spread in each cluster. The 12 clusters were then assigned to 12 months in a given order to ensure better representation for groups of months taken together. An independent sample was drawn for each sub-sample and was allotted to an investigator.

9.2. Two notable exceptions to this method of sampling were Kanpur and Kharagpur. In Kanpur, where the blocks had been classified as containing high, medium and very low working class concentrations during the preliminary enquiry for the Working Class Survey, the blocks containing high working class concentration were excluded from the Middle Class Survey. In the medium concentration stratum, for sampling for the Working Class Survey clusters of 2 blocks each had been formed which were made heterogeneous with respect to geographical location and type of working class inhabiting in them. For the Middle Class Survey in this stratum a systematic sample of 12 of these clusters was selected per sub-sample with probability proportional to the total population less the expected working class population (as estimated during the preliminary survey). The samplings for the Middle Class and Working Class Surveys were linked up in this stratum so as to ensure the maximum number of common clusters between them as this would be helpful in minimising the listing time for the enquiries. The blocks containing low working class concentration were treated as another stratum, for the Middle Class Survey and a simple systematic sample of 12 blocks was drawn per sub-sample in this stratum. Each sub-sample (in both the strata combined) was allotted to an investigator.

9.3. Kharagpur centre consists of a railway colony and a municipality. In the municipality it was possible to form residential blocks and collect information on the expected percentage of middle class employees in them, whereas, for the railway colony, it was found that sampling could be done from the card index which was kept 'section-wise' for every employee who had an allotted quarter in the colony. Each section was a cabinet in the card index and it covered mainly quarters for one type of workers, e.g., clerical, supervisory, engineering etc. The railway colony and municipal area were treated as two different strata and the payroll and tenement sampling methods respectively were adopted in them. In the first stratum 12 'sections' were selected per sub-sample systematically with probability proportional to the number of workers in them, and allotted to the 12 months. In the second stratum, clusters of two blocks each were formed by grouping together blocks with different middle class concentrations and situated in different areas. These clusters were arranged in decreasing order of the expected middle class population in them, and a simple systematic sample of 12 clusters was selected per sub-sample. Each sub-sample (in both the strata combined) was allotted to an investigator.

10. SELECTION OF ARTIFICIAL BLOCKS AND RANDOM ORDER OF VISIT

10.1. In cases where the blocks were very large, and too much time was taken for listing them or they were unidentifiable or were casualties because of lack of field staff, etc., the devices of artificial block division, random order of visit and substitution were adopted as in the case of tenement sampling for the Working Class Survey (see paragraphs 8.8, 8.9, 8.11 and 8.12 of Part 2).

11. SAMPLING OF FAMILIES

11.1. The investigator listed all the families in the blocks assigned for survey in a month and picked out the middle class families among them. These families were arranged by their size (single member families coming together, and then the others) and within the size groups by monthly expenditure classes (there were three expenditure classes — below Rs. 150 per month, Rs. 150 to Rs. 300 per month, and Rs. 300 and above per month). A simple systematic sample of 20 families was selected from this arranged list and every fifth family among them was investigated for Schedule B (level of living) and the others were investigated for Schedule A (pattern of consumer expenditure). The families were listed and selected in Schedule L(m), a facsimile copy of which is given in Appendix 4.

11.2. In the two centres, Kanpur and Kharagpur, where stratification was adopted, the allocation of families to the two strata was made proportional to their expected middle class populations. Sampling of families within each stratum was as in the unstratified case, except that in Kharagpur, in the stratum where payroll sampling was adopted, workers were sampled from the list of workers in the selected section by systematic sampling, any arrangement by type of work or grades being made use of, and the families to which these workers belonged were contacted for detailed enquiry if they satisfied the definition of middle class families.

12. SUBSTITUTION OF FAMILIES

12.1. In case a family could not be contacted due to various reasons, absolutely refused to give information in spite of all the means of persuation at the disposal of the investigating officer, or was found to be not a middle class family at the time of detailed enquiry, it was substituted by the next middle class family in the arranged list for that cluster.

12.2. If in a sampled cluster for a particular month the required number of middle class families (20) was not available, the deficiency was made up from the sampling frame for the next month's cluster for the same stratum (if any) and subsample so as to keep the total sample size unaltered.

PART 4. ESTIMATION PROCEDURE FOR THE WORKING AND MIDDLE CLASS FAMILY LIVING SURVEYS

1. TENEMENT SAMPLING CENTRES : SAMPLING SCHEMES

1.1. *Scheme* I. 36 blocks per sub-sample were selected systematically with equal probability and grouped into 12 clusters of 3 blocks each. Each sub-sample was allotted to an investigator and each cluster in it was to be surveyed in a particular month by him. The sub-samples were drawn independently for the different investigators. If some blocks were very large, the number of artificial block divisions to be formed in them was specified and the blocks were selected systematically with probability proportional to the number of such divisions. In any sampled block the number of artificial block divisions actually formed for the survey depended on its population size as observed in the field, and this could differ from the number specified earlier. In a block where such division was adopted, one of the artificial block divisions formed was selected at random with equal probability for survey.

1.2. All the working/middle class families in the blocks or selected artificial blocks of a sampled cluster were listed together and a sample of families was drawn from this list, systematically with equal probability for detailed enquiry.

1.3. In some centres the sampling scheme was modified as follows. A random order of visit was assigned to the 3 blocks within a cluster and only 1,2, or 3 of these blocks were surveyed depending on the total number of families listed and the number of working/middle class families obtained when the listing of each block (visited in the random order given) was completed.

1.4. *Scheme* II. A probability proportional to size systematic sample of 12 clusters of 3 blocks, each was drawn in some centres, size being the estimated number of working/middle class families and the procedure of random order of visit, artificial block selection and sampling of families within a cluster was the same as in Scheme I.

1.5. *Scheme* III. In some centres the blocks were grouped into 2 strata and selection of the allotted number of blocks or clusters was done independently in each stratum according to one of the methods I and II.

Notations : 'i' : denotes a sampled cluster of a sub-sample ; 'j' : denotes a block in the sampled cluster ; 'k' : denotes a sampled family in a block of the sampled cluster ; B : total number of blocks ; T : size adopted for pps sampling ; F : total number of working/middle class families in the sampled cluster (as obtained from the listing schedules) ; f : number of sample working/middle class families selected for a schedule in the sampled cluster ; b : number of blocks surveyed in the sampled cluster ; D : number of artificial block divisions specified in the sample list for a block ; D' : number of artificial block divisions actually formed in a block; y : value of the characteristic to be estimated.

1.6. *Estimation procedure.* The estimate of the total of y for each stratum/centre for a month and sub-sample for the different sampling schemes is given by $\sum_j \sum_k M_{ijk} Y_{ijk}$ where M_{ijk} is the multiplier for the k-th family in the j-th block of the i-th cluster (sub-sample) and is obtained as shown below :

For *Scheme* I :
$$M_{ijk} = \frac{B}{b_i} \cdot \frac{F_i}{f_i} \cdot \frac{D'_{ij}}{D_{ij}}$$

where B is the total number of blocks or specified artificial blocks in the stratum or centre, i.e., the summation of D over all the blocks in the stratum/centre, D being taken as 1 for a block where no artificial block division was specified.

For *Scheme* II :
$$M_{ijk} = \frac{T}{T_i} \cdot \frac{F_i}{f_i} \cdot \frac{B_i}{b_i} \cdot D'_{ij}$$

where T is the total of the size T_i for all the clusters in the stratum/centre.

B_i is the number of blocks in that cluster/total of the number of artificial blocks specified for the blocks in that cluster.

For *Scheme* III : The estimate is the sum of the estimates in the two strata, where the estimate in each stratum is arrived at using the multipliers as given for Scheme I or II depending on the method of sampling adopted in that stratum.

1.7. *Note :* (i) If r out of the k clusters (sub-samples) allotted for a month were casualties, the multiplier for that month is to be multiplied by the correction factor $\frac{k}{k-r}$.

(ii) The sub-sample-wise estimate of the monthly average for a characteristic or the sub-sample-wise estimate of the total number of families/persons in the centre is obtained by dividing the sum of the monthly estimates for that sub-sample by 12 (by 6 for single-investigator centre).

(iii) A simple average of the sub-sample estimates gives the combined estimate for the centre.

(iv) The sub-sample (or combined) estimate for the ratio of two characteristics is obtained by taking the ratio of the corresponding sub-sample (or combined) estimates.

2. PAYROLL SAMPLING CENTRES : SAMPLING SCHEMES

2.1. *Scheme* I. The establishments (factories/mines/plantations) in the centre were grouped to form clusters of 3, 4 or 5 establishments according to a suitable criterion and a sample of 12 such clusters per sub-sample was selected pps systematically (size being the number of workers as in the sampling frame). Each sub-sample was allotted to an investigator and each cluster was to be surveyed in a particular month by him. The sub-samples were drawn independently for each investigator.

2.2. All the workers in a sampled cluster were listed together and a systematic sample of workers was drawn from this list. The families to which these workers belonged were contacted for the detailed enquiry. (If two or more sampled workers belonged to the same family, the information for that family was repeated as many times as it was selected).

2.3. *Scheme* II. In some centres clusters were not formed ; the individual establishments were selected pps systematically and the number of workers to be sampled from each establishment was specified in the sample list. Sampling within each establishment was as within a cluster in Scheme I.

2.4. *Scheme* III. In some centres where the number of workers was not available for the frame for most of the establishments, 12 clusters of 3 or 4 establishments were selected systematically with equal probability. Sampling within a cluster was as in Scheme I.

2.5. *Scheme* IV. In some centres the establishments were grouped to form 2 strata and the selection was done by Scheme I, II or III in each stratum.

2.6. *Notations :* i : denotes a sample cluster of a sub-sample ; j : denotes an establishment in the sampled cluster ; k : denotes a sampled family in an establishment of the sampled cluster ; W : total number of workers as in the sampling frame ; W' : total number of workers as obtained in the listing schedule ; E : total number of establishments in the stratum/centre ; e : number of establishments in the sampled cluster ; f : number of families surveyed ; w : number of workers in the sampled family ; y : value of the characteristic to be estimated.

2.7. *Estimation procedure.* The estimate of the total Y for each stratum/centre for a month and sub-sample, for the different sampling schemes is given by $\sum\limits_{j}\sum\limits_{k} M_{ijk}\, Y_{ijk}$ where M_{ijk} is the multiplier for the k-th family in the j-th establishment of the i-th cluster and is obtained as shown below :

For *Scheme* I :
$$M_{ijk} = \frac{W}{W_i} \cdot \frac{W'_i}{f_i} \cdot \frac{1}{w_{ijk}}$$

where W is the total of W_i for all the clusters in the stratum/centre.

For *Scheme* II :
$$M_{ijk} = \frac{W}{e_i} \cdot \frac{W'_{ij}}{W_{ij}} \cdot \frac{1}{f_{ij}} \cdot \frac{1}{w_{ijk}}$$

For *Scheme* III :
$$M_{ijk} = \frac{E}{e_i} \cdot \frac{W'_i}{f_i} \cdot \frac{1}{w_{ijk}}$$

For *Scheme* IV : The estimate is the sum of the estimates in the two strata where the estimate in each stratum is arrived at using the multipliers given for Schemes I, II or III depending on the method of sampling adopted in that stratum.

2.8. *Note :* (i) If some establishment was substituted because it was a casualty, the number of workers in the cluster W'_i is obtained by adding the number of workers in the substitute establishment to the number of workers in the other establishments of the cluster.

(ii) If the establishment was a casualty and was not substituted, the number of workers W_i is obtained by adding the number of workers in the other surveyed establishments of the cluster.

(iii) If r out of the k clusters (sub-samples) allotted for a month were casualties, the multiplier for that month is to be multiplied by the correction factor $\frac{k}{k-r}$.

(iv) The sub-sample-wise estimate of the monthly average for a characteristic or the sub-sample-wise estimate of the total number of families/persons in the centre is obtained by dividing the sum of the monthly estimates for that sub-sample by 12 (by 6 for single-investigator centre).

(v) A simple average of the sub-sample estimates gives the combined estimate for the centre.

(vi) The sub-sample (or combined) estimate for the ratio of two characteristics is obtained by taking the ratio of the corresponding sub-sample (or combined) estimates.

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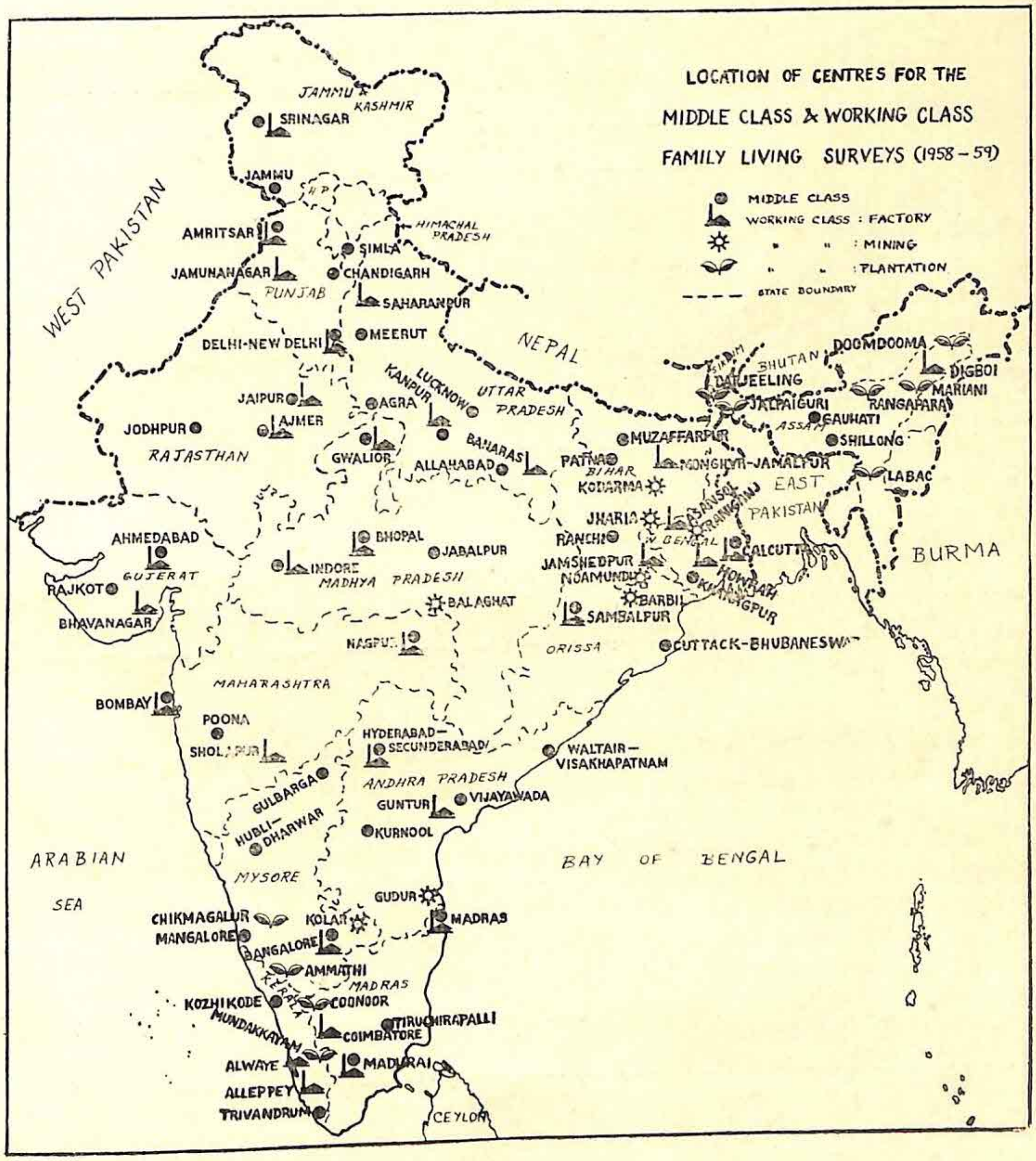
LOCATION OF CENTRES FOR THE
MIDDLE CLASS & WORKING CLASS
FAMILY LIVING SURVEYS (1958-59)
● MIDDLE CLASS
WORKING CLASS : FACTORY
" " : MINING
" " : PLANTATION
STATE BOUNDARY
JAMMU & KASHMIR
SRINAGAR
JAMMU
H.P.
HIMACHAL PRADESH
WEST PAKISTAN
AMRITSAR
SIMLA
JAMUNANAGAR
CHANDIGARH
PUNJAB
SAHARANPUR
DELHI-NEW DELHI
MEERUT
NEPAL
JAIPUR
KANPUR
LUCKNOW
UTTAR PRADESH
AGRA
AJMER
JODHPUR
RAJASTHAN
GWALIOR
BANARAS
ALLAHABAD
PATNA
BIHAR
MUZAFFARPUR
MONGHYR-JAMALPUR
KODARMA
SIKKIM
BHUTAN
DARJEELING
JALPAIGURI
DOOMDOOMA
DIGBOI
MARIANI
RANGAPARA
ASSAM
GAUHATI
SHILLONG
LABAC
EAST PAKISTAN
BURMA
AHMEDABAD
GUJERAT
RAJKOT
BHAVANAGAR
BHOPAL
INDORE
JABALPUR
MADHYA PRADESH
BALAGHAT
JHARIA
ASANSOL
RANIGANJ
RANCHI
W. BENGAL
CALCUTTA
JAMSHEDPUR
NOAMUNDI
HOWRAH
KHARAGPUR
BARBIL
SAMBALPUR
ORISSA
CUTTACK-BHUBANESWAR
NAGPUR
MAHARASHTRA
BOMBAY
POONA
SHOLAPUR
HYDERABAD-SECUNDERABAD
WALTAIR-VISAKHAPATNAM
GULBARGA
ANDHRA PRADESH
GUNTUR
VIJAYAWADA
HUBLI-DHARWAR
KURNOOL
ARABIAN SEA
BAY OF BENGAL
MYSORE
GUDUR
CHIKMAGALUR
KOLAR
MADRAS
MANGALORE
BANGALORE
AMMATHI
KERALA
MADRAS
KOZHIKODE
COONOOR
MUNDAKKAYAM
COIMBATORE
TIRUCHIRAPALLI
ALWAYE
MADURAI
ALLEPPEY
TRIVANDRUM
CEYLON

Appendix 1

LIST OF CENTRES FOR THE WORKING CLASS FAMILY LIVING SURVEY SHOWING TYPE OF CENTRE, MAIN INDUSTRIES, NUMBER OF INVESTIGATORS, SAMPLE SIZE, SAMPLING FRAME (BOUNDARIES OF CENTRE) AND SAMPLING METHOD USED

srl. no.	state	centre	type	main industries	number of investigators	sample size for schedule A	sample size for schedule B
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	Andhra Pradesh	Guntur	factory	tobacco	1	180	60

Sampling frame : Guntur municipality excluding 7 unimportant localities (census numbers 9, 10, 21, 22, 23, 24 and 27) which were mainly middle class or shopping areas and would cover about 15% of the working class population in the municipality, and including 7 neighbouring villages, viz. Thakkellapadu, Etakuru, Budampadu, Gorantla, Kakani, Agathavarappadu and Kornepadu were covered by the survey. During the preliminary enquiry blocks were formed in the area within the municipality to be covered by the survey, and the list of these blocks and the 7 villages was used as the sampling frame.

Sampling method : Tenement sampling was adopted. 2 independent simple systematic samples each consisting of 6 clusters (of 3 blocks each or one village each) were selected. The clusters were formed by arranging the blocks in the odd numbered census localities in increasing order of population and those in even numbered localities in decreasing order of population and grouping together every 20th block, so that no two blocks in a cluster belonged to the same census locality, and the population content of the clusters were roughly equal. One of the villages which was small was treated as a block for this arrangement.

2	Andhra Pradesh	Hyderabad	factory	printing, rice, dal, oil, saw-mills	2	480	120

Sampling frame : The list of factories for the year ending 1956 registered under the Factories Act in Hyderabad city, including those registered under section 85(*i*) of the Act, was the sampling frame. There were 404 factories in all.

Sampling method : Payroll sampling was adopted. Factories employing 50 or more workers constituted stratum 1, and the rest, stratum 2. In the first stratum 2 independent samples of 12 factories each were selected systematically with probability proportional to number of workers after arranging the factories in increasing order of the number of workers. In the second stratum, factories were arranged by the industry type (all factories under section 85 (*i*) were put together) and 2 independent simple systematic samples of 36 factories each were selected. In each sub-sample, these factories were clustered into 12 groups of 3 each in a systematic manner.

3	Andhra Pradesh	Gudur	mining	mica mining	1	240	60

Sampling frame : The list of mines registered under the Mines Act in the Rapur taluk (adjoining Gudur town) of Nellore district was the sampling frame. 41 mines were covered thereby.

Sampling method : Payroll sampling was adopted. The mines had been grouped into 4 regions by the Labour Welfare Advisory Board for convenience of administration—Sydapuram, Utukur, Kalichedu and Tummalatalupur with 10, 10, 10 and 11 mines respectively in them. Clusters of 4 mines each were formed by taking one mine from each region (except in one case where 2 mines were taken from the last region) in such a way that mines of different sizes (number of workers) were represented in a cluster. The clusters were arranged in increasing order of size and 2 independent systematic samples of 6 clusters each were selected systematically with probability proportional to size.

srl. no.	state	centre	type	main industries	number of investigators	sample size for schedule	
						A	B
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
4	Assam	Digboi	factory	petroleum refinery and related industries	1	240	60

Sampling frame : The list of factories in Digboi for the year ending March 1958 registered under the Factories Act, was the sampling frame. 28 factories were covered in all of which 3 were factories in tea estates, 6 were saw mills and the remaining were concerns of the Assam Oil Company.

Sampling method : Payroll sampling was adopted. The 4 factories employing 250 workers or more constituted stratum 1, and the remaining formed stratum 2. In each stratum clusters of 2 factories each were formed, and 2 independent samples of 6 clusters each were selected systematically with probability proportional to the number of workers in the cluster after arranging the clusters in decreasing order of total number of workers in them.

5	Assam	Doom-dooma	plantation	tea	2	480	120

Sampling frame : The list of registered plantation within 10 miles of Doom-dooma was the sampling frame used. The list consisted of 22 plantations.

Sampling method : Payroll sampling was adopted. 8 clusters of 2 or 3 plantations each were formed so that all the plantations in a cluster belonged to the same postal region. Attempts were also made to represent in each cluster plantations under different managements (foreign, Indian) and of different sizes. Two independent samples of 12 clusters each were selected systematically with probability proportional to the number of workers in the cluster.

6	Assam	Labac	plantation	tea	1	240	60

Sampling frame : The list of registered plantations in the 'Lakhimpur circle' (which includes Labac) as defined by the Indian Tea Association was the sampling frame. There were 9 plantations in all.

Sampling method : Payroll sampling was adopted. 1 cluster of 3 plantations and 3 clusters of 2 plantations each were formed by grouping together plantations which were close by and of different sizes (number of workers). Two independent sub-samples of 6 clusters each were selected systematically with probability proportional to the number of workers employed after arranging the clusters in increasing order of size.

7	Assam	Mariani	plantation	tea	1	240	60

Sampling frame : The list of registered plantations within 10 miles of Mariani was the sampling frames. There were 25 such plantations.

Sampling method : Payroll sampling was adopted. Cluster of 3 or 4 plantations each were formed so as to represent within each cluster, plantations under foreign and Indian management, and plantations of varying employment sizes. The clusters were arranged in increasing order of the size and 2 independent samples of 6 clusters each were selected systematically with probability proportional to size.

8	Assam	Rangapara	plantation	tea	2	480	120

Sampling frame : The sampling frame was the list of registered plantations within a distance of 10 miles from Rangapara centre, consisting of 24 plantations in all.

Sampling method : Payroll sampling was adopted. Clusters were formed by grouping together 3 neighbouring plantations, such that each cluster consisted of at least one plantation employing casual labour and one employing permanent labour. Attempts were also made to ensure in each cluster representation for plantations under at least 2 of the 4 different managing agents. Two independent samples of 12 clusters each were selected systematically with probability proportional to the number of workers in the cluster.

srl. no.	state	centre	type	main industries	number of investigators	sample size for schedule	
						A	B
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
9	Bihar	Jamshedpur	factory	iron and steel, engineering	4	720	240

Sampling frame : Working class families living in (i) the area under TISCO administration (ii) quarters of other factories in Jamshedpur (iii) Jugsalai notified area and (iv) the adjoining villages of Mango, Dimua, Balogoma, Paridih, Mirjadih, Kapali, Dindli, Bagbera, Keruadungri, Hargarghutto, Kitadih, Karandih, Sundargarh, Khasmahal, Parsudih, Silgajon, Malshdumpur, and Manifit formed the sampling frame.

Sampling method : Tenement sampling was adopted. The area to be covered by the survey was divided into blocks, each block being a group of adjacent roads in a locality containing quarters of similar type. Since some of the blocks and villages were very large, the number of artificial blocks to be formed in them were decided before sampling. The blocks were arranged by geographical contiguity. 3 independent simple systematic samples of 36 blocks or villages each were sampled with probability proportional to the number of artificial blocks in them and blocks within each sub-sample were grouped systematically into clusters of 3 blocks each using the same arrangements.

10	Bihar	Monghyr-Jamalpur	factory	locomotives, tobacco, printing	2	480	120

Sampling frame : The list of registered factories in the towns of Jamalpur and Monghyr for the year ending 1957, including those registered under section 85(1) of the Act, was the sampling frame. 91 factories in all were covered.

Sampling method : Payroll sampling method was adopted. The four big factories — Imperial Tobacco Co., Monghyr Printing Factory, Locomotive & General Works and Power House & Electric Workshop which together accounted for about 90% of the workers in the centre, constituted stratum 1. The remaining factories constituted stratum 2. In stratum 1, 2 independent samples of 12 factories each were selected pps* systematically, size being number of workers. In stratum 2, the factories were arranged by industries, and within each industry by towns. Clusters of 3, 4 or 5 factories each were formed by grouping together nearby factories in this arranged list such that each cluster contained a sizeable number of workers. 2 independent pps systematic samples of 12 clusters each were drawn from the list, size being number of workers.

11	Bihar	Jharia	mining	coal	4	960	240

Sampling frame : The 1956 list of registered mines in Jharia, covering 363 mines in all was the sampling frame.

Sampling method : Payroll sampling was adopted. Since the mines were spread over a large area, they were first of all marked off into 8 compact regions, each region containing a sizeable number of mines, such that distances between the mines within a region was not too much. Within each region the mines were clustered into groups of 3 mines each such that the number of workers in each cluster was nearly equal and each cluster contained one large and two small mines. All the clusters in the centre were then arranged in increasing order of the number of workers employed and 4 independent pps systematic samples of 12 clusters each were drawn, size being the number of workers.

12	Bihar	Kodarma	mining	mica	1	240	60

Sampling frame : The sampling frame consisted of the list of 494 registered mines situated within a radius of about 80 miles from Kodarma. The entire list of mines in the Kodarma mica belt was not included as that would have covered a large area spread over 3 districts.

Sampling method : Payroll sampling was adopted. The mines were grouped into clusters of 2 or 3 nearby mines, usually belonging to the same owner and 2 independent simple systematic samples of 6 clusters each were drawn.

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* pps : probability proportional to size.

srl. no.	state	centre	type	main industries	number of investigators	sample size for schedule	
						A	B
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
13	Bihar	Noamundi	mining	iron	1	240	60

Sampling frame : Workers were sampled from the only mine in Noamundi — The Tata Iron Mines.

Sampling method : Payroll sampling was adopted.

14	Delhi	Delhi	factory	textile, printing, electricals	4	720	240

Sampling frame : The following localities were covered (i) wards 12, 13, 14, 16 and 20 of Delhi, (ii) ward 6 of New Delhi, (iii) ward 1 of Sahadara municipality and (iv) villages, Tahirpur and Gokalpur.

Sampling method : Tenement sampling was adopted. 4 independent simple systematic samples of 36 blocks (or villages) each were selected, the arrangement being as in the list supplied by the Field during the preliminary enquiries (when the blocks were formed) by wards and towns or villages. Within each sample, the blocks were grouped systematically into clusters of 3 each using the same arrangement.

15	Gujerat (earlier Bombay State)	Ahmedabad	factory	textiles	4	720	240

Sampling frame : The survey covered the following localities :

(i) the Chawls of the following 16 (out of 32) wards in Ahmedabad city which contain about 90% of the working class population of the city — Gomtipur para B-2, Saraspur para B-1 & B-2, Kalupur, Behrampur para 9, Asarwa, Shahpur, Shahpur — 2, Khobhra Mehmedabad para D, Daraipur, Jamalpur, Raikhad, Ellis Bridge North, Ellis Bridge South, Rajpur para A-3, Kankaria, Rakhial para F ;

(ii) the following 21 labour colonies (housing societies) — Sutaria, Budhnagar, Gantamnagar, Nandanagar, Shree Ashram, Chandra Prakash (parts 1, 2 and 3), Maheshwari, Uttar Gujerat Harijan, Shree Jai Somnath, Shree Rajendra, Shree Sukhramnagar, Shree Hinghlaj, Shree Patel, Bagiatinagar, Shree Green Cross, Shree Kamnath, Chotabhai, Rana Bapunagar, Rakhial colony, Housing Board colony, and additional Rakhial colony ;

(iii) the villages of Naroda, Rakhial (Bapunagar), Sahijpur, Boga, Wadaj, Dani Limbda, Hansol, Qdhari and Kochral.

Sampling design : Tenement sampling method was adopted. The Chawls within each of the wards listed under (i) above were grouped to form blocks of about 150 households each and these blocks along with the colonies listed under (ii) were grouped to form clusters of about 450 households each such that each cluster had blocks from different wards. From the list of these clusters and villages listed under (iii) 4 independent simple systematic sample of 12 clusters or villages each were selected for survey.

16	Gujerat (earlier Bombay State)	Bhavnagar	factory	textile, printing, oil	1	240	60

Sampling frame : The list of factories for the year 1957 registered under the Factories Act in Bhavnagar was used as the sampling frame. The list contained 108 factories.

Sampling design : Payroll sampling was adopted. The factories were grouped into clusters of 4 factories each such that within a cluster there was representation from factories belonging to different industries and of different sizes. Two independent pps systematic samples of 6 clusters each were drawn, size being the number of workers, from the list of clusters arranged in decreasing order of number of workers.

srl. no.	state	centre	type	main industries	number of investigators	sample size for schedule	
						A	B
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
17	Jammu and Kashmir	Srinagar	factory	silk, wool, printing, drugs, saw-mills	2	480	120

Sampling frame : The list of registered factories in Srinagar for the year ending 1957 was used as the sampling frame. There were 32 factories in all.

Sampling method : Payroll sampling was adopted. The factories were arranged in decreasing order of the number of workers employed and grouped systematically into clusters of 4 factories each so as to have representation from factories of different sizes in each cluster. The clusters were arranged in decreasing order of the number of workers employed and 2 independent samples of 12 clusters each were selected systematically, with probability proportional to the number of workers.

18	Kerala	Alleppey	factory	coir, oil	2	360	120

Sampling frame : The whole municipal area of Alleppey excluding the 15 wards listed in the following sentence, and including the panchayath areas of Mannacheri, Mararikulan and Pannapan was considered as the sampling frame. The wards excluded from the survey were : Zacharia Bazar, Beach, Lajanath, Municipal office ward, Palace, Pallatharuthi, Seaview, Factory, Market, Mullakarai, Boatjetty, Thirumala, Sanathanam, Zillacourt, and Thathampully.

Sampling method : Tenement sampling method was adopted. The area covered by the sampling frame was divided into artificial blocks of 150 to 200 households each ; of the 88 blocks, 7 were omitted because they contained negligible working class concentration. The remaining blocks were grouped into clusters of 3 blocks each such that no two blocks in a cluster belonged to the same ward, and the cluster sizes were equalised with respect to the number of workers residing in them. The clusters were arranged in decreasing order of number of workers and 2 independent simple systematic samples of 12 clusters each were selected.

19	Kerala	Alwaye	factory	tile, potteries, chemicals	1	240	60

Sampling frame : The list of 19 registered factories for the year ending 1957 which included factories situated within a radius of 10 miles of Alwaye was the sampling frame.

Sampling method : Payroll sampling method was adopted. The factories were grouped to form clusters of 3 or 4 factories each such that within each group there was representation from different industries, sections and sizes. The clusters were arranged in increasing order of size and 2 independent samples of 6 clusters each were selected systematically with probability proportional to their sizes (number of workers).

20	Kerala	Mundakkayam	plantation	rubber, tea	1	240	60

Sampling frame : The list of 19 registered rubber and tea estates situated within a radius of 7 miles from Mundakkayam for the year ending 1957 was the sampling frame.

Sampling method : Payroll sampling was adopted. 5 clusters of 3 or 4 estates each were formed such that 2 estates in each cluster were rubber estates and the rest were tea. An attempt was made to group within a cluster both large and small estates to have adequate representation of size. Two independent samples of 6 clusters each were selected systematically with probability proportional to the number of workers in the cluster.

srl. no.	state	centre	type	main industries	number of investigators	sample size for schedule	
						A	B
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
21	Madhya Pradesh	Bhopal	factory	textile, beedi, wooden furniture	1	240	60

Sampling frame : The list of 34 registered factories in Bhopal for the year ending 1957 was the sampling frame.

Sampling method : Payroll sampling was adopted. There was one big factory — The New Bhopal Textiles Ltd., which constituted stratum 1 and was surveyed every month. The rest of the factories were grouped to form clusters such that the factories within a cluster were of varying sizes. The clusters were arranged in decreasing order of number of workers and 2 independent samples of 6 clusters each were selected systematically with probability proportional to the number of workers in the cluster.

22	Madhya Pradesh	Gwalior	factory	textile, engineering leather and cane works	2	360	120

Sampling frame : All the labour areas within Gwalior municipal corporation, namely — the labour colony of the T. C. Mills, subsidised industrial colony adjacent to Motilal Mills, subsidised industrial colony in Noorganj and the labour localities in Gwalior town, Morar and Lashkar city were covered in the sampling frame.

Sampling method : Tenement sampling was adopted. Artificial blocks were formed within the above localities. These blocks were grouped to form clusters of 3 blocks each such that within each cluster, workers in different industries and coming from different States were represented and such that the cluster sizes were equalised with respect to the number of workers residing in them. 2 independent simple systematic samples of 12 clusters each were selected with equal probability.

23	Madhya Pradesh	Indore	factory	textile, printing	2	480	120

Sampling frame : The list of registered factories in Indore for the year 1957 including 10 factories situated in the neighbourhood of Indore was used as the frame.

Sampling method : Payroll sampling was adopted. There were two strata. Stratum 1 consisted of factories employing 2000 or more workers each. In this stratum 2 independent samples of 12 factories each were selected systematically with probability proportional to number of workers employed after arranging the factories in decreasing order of number of workers. The rest of the factories constituted stratum 2. These factories were grouped into clusters of 3 or 4 factories each such that each cluster was heterogeneous with respect to industry and number of workers employed. The clusters were arranged in decreasing order of number of workers and 2 independent samples of 12 clusters each were selected systematically with probability proportional to the number of workers in the cluster.

24	Madhya Pradesh	Balaghat	mining	manganese	1	240	60

Sampling frame : The 6 registered working mines within a radius of 5 miles of Balaghat town constituted the sampling frame.

Sampling method : Payroll sampling was adopted. The Bharweli Mines owned by the Central Provinces Manganese Ore Company which employed about 70% of the labour in this area constituted stratum 1. The remaining 5 mines constituted stratum 2. The mine in stratum 1 was surveyed every month. In stratum 2, the mines were arranged in decreasing order of number of workers and 2 independent samples of 6 mines each (a mine could be repeated in the sample and therefore allotted to two months since the number of mines 5, was lesser then the number of months, 6) were selected systematically with probability proportional to number of workers.

srl. no.	state	centre	type	main industries	number of investigators	sample size for schedule	
						A	B
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
25	Madras	Coimbatore	factory	textile, printing, rice-mill	3	720	180

Sampling frame : The list of registered factories for the year 1957 in Coimbatore town and the 10 adjoining villages of Singanallur, Upplipalayana, Sowripalayam, Udayanpalayan, Kurichi, Peelamedu, Ganapathy, Kuniamathur, Vellalur and Telungapalayam was used as the sampling frame. 268 factories were covered in all.

Sampling method : Payroll sampling was adopted. 52 factories where the number of workers employed was relatively high, constituted stratum 1. The rest of the factories constituted stratum 2. In stratum 1 clusters of 2 factories each were formed such that each cluster represented 2 different industries and such that the cluster sizes were nearly equal. 3 independent samples of 12 clusters each were selected systematically with probability proportional to the number of workers employed in the cluster after arranging the clusters in increasing order of number of workers. In stratum 2 the factories were grouped into clusters of 2 or 3 factories each and arranged as in stratum 1, and 3 independent samples of 12 clusters each were selected systematically with probability proportional to the number of workers employed.

26	Madras	Madras	factory	textile, engineering	4	960	240

Sampling frame : The list of 784 registered factories for the year 1957 situated in circle I and circle II of Madras city, (as defined by the Chief Inspector of Factories) was used as the sampling frame.

Sampling method : Payroll sampling was adopted. Stratum 1 consisted of factories which employed 100 workers or more each. In this stratum, clusters of 2 factories each were formed, such that each cluster contained factories of different industries, sectors, management types and sizes. The clusters were arranged in increasing order of size, and 4 independent pps systematic samples of 12 clusters each were drawn, size being number of workers employed. In stratum 2, 4 independent samples of 24 factories each were selected systematically with probability proportional to number of workers, and within each sample the factories were grouped in a systematic manner to form 12 groups.

27	Madras	Madurai	factory	textile	2	360	120

Sampling frame : The following wards within the municipal limits of Madurai, numbers 1 to 3, 6 to 11, 24, 29 and 30 to 32, and 3 localities outside the town viz., Palanganatham of Madakulam village, Harveypalli and Meenakshi Mill Colony were covered by the sampling frame.

Sampling method : Tenement sampling was adopted. The area covered by the sampling frame was divided into artificial blocks of about 150 to 200 households each. Clusters of 3 blocks each were formed such that the blocks within a cluster belonged to different wards and the number of workers residing in each cluster was roughly equal. The clusters were arranged in decreasing order of number of workers and 3 independent samples of 12 clusters each were selected systematically with probability proportional to the number of workers in the clusters.

28	Madras	Coonoor	plantation	tea, coffee	1	240	60

Sampling frame : The list of 110 registered plantations situated in Coonoor taluk (including one plantation in Ooty taluk which was very near Coonoor) covering about 90% of the area of the taluk was considered as the sampling frame.

Sampling method : Payroll sampling was adopted. Because of difficulties in communication between plantations in different villages, the plantations within a village or town were grouped into clusters of 3 each, by type of plantation. 2 independent pps systematic samples of 6 clusters each were selected, size being number of workers employed.

srl. no.	state	centre	type	main industries	number of investigators	sample size for schedule	
						A	B
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
29	Maharashtra (earlier Bombay State)	Bombay	factory	information not available in preliminary inquiry schedules	8	1440	480

Sampling frame : The sampling frame covered the working class localities in 35 (out of the 44) census wards in Bombay, and some important labour localities which had sprung up after the 1951 census. This frame which covered the Bombay municipal corporation (Bombay city and suburban areas) was expected to cover about 90% of the workers employed in registered factories in Bombay. Given below is the list of the census wards (with their numbers) included in the frame: Colaba (1)*, Mandir (4)*, Dongari (5)*, Umarkhadi (6)*, Khara talao (7)*, Kumbarwada (8)*, Panawadi (11), Khetwadi (13), Mahalaxmi (15), Tardeo (16), Kamathi Pura (17), Nagpada (18), Mazgaon (including Harbour Docks) (19), Byculla (East) (21), Ghorupdeo (Mazgaon) (22), Sewri (23), Lalbaug (24), Parel (25), Naigaum (26), Matunga (27), Sion (28), Love Grove (including Chinchpohli) (29), Lower Parel (30), Worli (31), Prabhadevi (32), Dadar (33), Mahim (34), Bandra (35 and 36), Andheri (37 and 38), Kurla (39), Chembur (40), Chalpokar (41) and Juhu. The other important labour localities included were Chembur Survey Nos. 14 and 68-71, Worli foot of Hills, Andheri, Parel tank, Bandra Survey No. 341, Goregaon and Worli N.U.A. III (The areas with * mark against them were not included in the months of survey, July-September. They were included later at the suggestion of the Deputy Commissioner of Labour).

Sampling method : Tenement sampling method was adopted. The total number of blocks in the sampling frame was 1047 for the months, July to September. For the remaining months, the coverage of the sampling frame was increased and 1187 blocks were sampled from. For the first 3 months 8 independent simple systematic samples of 36 blocks each were selected. The 36 blocks in a sample were grouped systematically into 12 clusters of 3 blocks. For the remaining months this sample was cancelled and 8 independent samples of 27 blocks each were selected systematically from the new frame and the blocks within each sample were clustered in the same manner as described above into 9 clusters of 3 blocks each.

30	Maharashtra (earlier Bombay State)	Nagpur	factory	textile, railway workshop, saw-mill, wooden furniture, engineering	3	720	180

Sampling frame : The list of 263 registered factories in Nagpur for the year ending March 1958 was used as the sampling frame.

Sampling method : Payroll sampling was adopted. The 7 big factories which employed 1000 workers or more each were separated to form stratum 1. These were arranged in decreasing order of size and 3 independent samples of 12 factories each were drawn systematically with probability proportional to number of workers. The remaining factories constituted stratum 2. These factories were grouped into clusters of 4 factories each such that in each cluster there was representation from factories of different size classes and industry types. The clusters were arranged in increasing order of size and 3 independent samples of 12 clusters each were selected systematically with probability proportional to number of workers employed.

srl. no.	state	centre	type	main industries	number of investigators	sample size for schedule A	sample size for schedule B
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
31	Maharashtra (earlier Bombay State)	Sholapur	factory	textile, printing, oil, tobacco	3	540	180

Sampling frame : The sampling frame covered 1951 census blocks in Sholapur municipality where the proportion of working class population was 10% or more and 12 neighbouring areas — the villages of Soregaon ; Bale ; Sholapur Waste ; Ward No. 1, Ward No. 9 of Sholapur Wadi ; Block No. 10 and Block No. 12 of Salgur Wadi ; Degaon ; Kunithi ; Shelgi ; Blocks 1-4 and Block 6 of Sholapur Basti.

Sampling method : Tenement sampling method was adopted. The blocks and areas were grouped into clusters of 3 each such that each cluster had blocks from different areas, with differing working class proportions and such that the total number of households in the clusters were more or less equal. The clusters were arranged in increasing order of the number of factory workers residing in them and 3 independent samples of 12 clusters each were selected systematically with probability proportional to number of factory workers.

32	Mysore	Bangalore	factory	aircraft, machine tools, electric engineering, textile	4	720	240

Sampling frame : The following 20 wards of Bangalore city which together accounted for about 90% of the workers residing within the city and 9 neighbouring villages listed below were covered by sampling frame.

Wards : 3 to 5, 8 to 11, 13 to 17, 23, 29 to 31, 33, 35, 37, 40.

Villages : Byatarayanapura, Yeshwantapura, Subrahmanyapura, Hebbal, Duravaninagar, Utharunahalli, Chickbanavar, H.A.L. Colony, Kodihalli.

Sampling method : Tenement sampling was adopted. The blocks covered by the sampling frame were divided into 2 strata. Stratum 1 consisted of the 9 villages and blocks within the city having proportion of working class population as 80% or more and stratum 2 consisted of blocks within the city having more than 10% but less than 80% of working class population proportions. The other blocks were excluded from the survey. In stratum 1, blocks were arranged in increasing order of number of workers, and 4 independent samples of 12 blocks each were selected systematically with probability proportional to number of workers. In stratum 2, the blocks were grouped to form clusters of 2 blocks each such that there was representation in each cluster of workers from different industries and the cluster sizes were roughly equal with respect to number of workers. The clusters were arranged in increasing order of number of workers and 4 independent systematic samples of 12 clusters each were selected with probability proportional to the number of workers in the clusters.

33	Mysore	Kolar Gold Fields	mining	gold	1	180	60

Sampling frame : The Kolar Gold Fields area included 3 gold mines — the Champion Reef Mine, Mysore Mine and Nandi Droog Mine besides the KGF electricity department which was also registered under the Mines Act. The survey was confined to the labour colonies of these mines and the electricity department which together shelter about 80% of the workers and the following 10 neighbouring villages which have a substantial number of workers residing in them — Andersonpet, Champion Reef, Gollapalli, Kottur, Kambliyor, Maskam, Oorgaum (because this village had a large number of workers it was divided into two parts the area in which workers in Nandidroog Mine resided and the area in which workers in the other mines resided composing the two parts), Robertsonpet (this was treated as 3 parts, — residences of the workers of Champion Reef, and the Electricity Department forming the first two parts and the rest forming the third part), Chinnapalli, and Andersonpet.

srl. no.	state	centre	type	main industries	number of investigators	sample size for schedule	
						A	B
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)

Sampling method : Tenement sampling was adopted. The labour colonies, or blocks or sub-areas within labour colonies were grouped together within each mine to form blocks of about 100 houses each. From the list of these blocks and villages or parts of villages, 2 independent simple systematic samples of 18 blocks or villages each were selected with equal probability and were grouped into 6 sets of 3 each in a systematic manner.

34	Mysore	Ammathi	plantation	coffee	1	240	60

Sampling frame : The 61 estates in Ammathi area, coming under the purview of the Plantation Act, were covered by the survey.

Sampling method : Payroll sampling was adopted. The estates were clustered into groups of about 3 each within postal regions such that in each group there were 2 estates with area 50 acres and above and 1 with area less than 50 acres and there was representation from Foreign and Indian management. The clusters were arranged in decreasing order of number of workers employed and 2 independent samples of 6 clusters each were selected systematically with probability proportional to the number of workers employed.

35	Mysore	Chikmagalur	plantation	coffee and cardamon	2	480	120

Sampling frame : The list of 217 estates in Chikmagalur Taluk of area 25 acres or more prepared in consultation with the officers of the Indian Coffee Board and the Labour Department of the State Government was used as the sampling frame.

Sampling method : Payroll sampling was adopted. The estates were grouped into clusters of 3 each such that estates of different areas were represented in each cluster. The clusters were then arranged in increasing order of their areas and 2 independent samples of 12 clusters each were selected systematically with probability proportional to the cluster areas. (Information on number of workers was not available, and it was learnt that the number employed is almost proportional to area).

36	Orissa	Sambalpur	factory	saw mill, bidi	1	240	60

Sampling frame : The list of 30 registered factories in Sambalpur for the year 1957 was used as the sampling frame.

Sampling method : Payroll sampling was adopted. The factories were grouped to form clusters of 4 or 5 factories each such that the total number of workers employed in the clusters was equalised and there was representation from both bidi factories and saw mills in each cluster. The clusters were arranged in decreasing order of size and 2 independent pps systematic samples of 6 clusters each were selected, size being number of workers employed.

37	Orissa	Barbil	mining	iron, manganese	1	240	60

Sampling frame : The list of 47 registered mines for the year 1957 situated within a radius of 25 miles around Barbil was used as the sampling frame. 'Barbil Depot' which is the centre where all the mine-owners of Barbil stock the ores and load it to the railway wagons, was also included in the frame.

srl. no.	state	centre	type	main industries	number of investigators	sample size for schedule	
						A	B
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)

Sampling method : Payroll sampling was adopted. The mines were classified into 3 classes by their output—class A consisting of mines having output above 1000 tons, class B between 200 to 1000 tons and class C, below 200 tons. The mines were arranged by class and within class by number of workers employed. 2 independent samples of 12 mines each were selected systematically with probability proportional to number of workers employed. The mines in each sample were paired in a systematic manner to form 6 clusters of 2 mines each.

38	Punjab	Amritsar	factory	textile, general engineering, loco-workshop	3	540	180

Sampling frame : The following localities were covered : municipal divisions 1, 3, 7, 9, 14, 15 and 16 within Amritsar town, Chherta municipal area and the villages, Verka, Abadi and Mustabad.

Sampling method : Tenement sampling was used. The areas in the sampling frame of Amritsar town and Chherta municipality were divided into blocks roughly of the size of 1951 census blocks. These blocks and the villages were grouped to form clusters of 2 or 3 blocks or villages each such that each cluster was heterogeneous with respect to the industries in which employed and States of origin of the residents. The clusters were arranged in increasing order of their working class population and 3 independent samples of 12 clusters each were selected systematically with probability proportional to the working class populations.

39	Punjab	Jamunanagar	factory	metal works, saw mill, general engineering	1	240	60

Sampling frame : The list of 114 registered factories in Jamunanagar for the year 1957 was used as the sampling frame.

Sampling method : Payroll sampling was adopted. The factories were arranged by industries and within industries by number of workers employed and 2 independent samples of 24 factories each were selected systematically with probability proportional to the number of workers employed. The factories in each sample were grouped into clusters of 4 each systematically using the same arrangement.

40	Rajasthan	Ajmer	factory	railway workshop	2	360	120

Sampling frame : The following 16 municipal wards out of the 32 in Ajmer were covered by the sampling frame — ward numbers 4, 5, 15, 16, 19, 20, 23 — 32.

Sampling method : Tenement sampling was adopted. Artificial blocks of 150—200 households each were formed in the area to be covered by the survey and these were arranged by wards and within wards, by geographical nearness. Clusters of 3 blocks each were formed by grouping these blocks in a systematic manner from this list. 2 independent simple systematic samples of 12 clusters each were selected.

41	Rajasthan	Jaipur	factory	printing, general electricals	1	240	60

Sampling frame : The list of 54 registered factories within 5 miles of Jaipur was used as the sampling frame.

srl. no.	state	centre	type	main industries	number of investigators	sample size for schedule	
						A	B
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)

Sampling method : Payroll sampling was adopted. All factories which employed 100 or more workers and the single foreign factory were put in stratum 1. The remaining factories were put in stratum 2. In stratum 1, clusters of 3 factories each were formed such that each cluster was heterogeneous with respect to size and industry type. These clusters were arranged in increasing order of size and 2 independent samples of 6 clusters each were selected systematically with probability proportional to size. In stratum 2 also, clustering and sampling was as in stratum 1.

42	Uttar Pradesh	Benaras	factory	printing, silk, electricity	1	240	60

Sampling frame : The list of 82 registered factories in Benaras circle (Benaras, Sheopur, Ram Nagar and Moghalsarai) was used as the sampling frame.

Sampling method : Payroll sampling was adopted. The factories were grouped to form clusters of 4 or 5 factories each such that each cluster had representation from factories of different industries, sectors and sizes. These clusters were arranged in increasing order of workers employed and 2 independent systematic samples of 6 clusters each were selected with probability proportional to number of workers employed.

43	Uttar Pradesh	Kanpur	factory	sugar, leather, wool	4	720	240

Sampling frame : All mohallas/chawks within Kanpur having working class population of 5 per cent or more and all the labour colonies were included in the sampling frame, as also the following 9 villages—Rajidpur, Gujjupurwa, Sujatganj, Tatia (Singha), Pokhar Purwa, Chaukhera, Mawaiya, Safiapur and Quazikhera.

Sampling method : Tenement sampling was adopted. The area to be covered was divided into artificial blocks of 150 or 200 households each and the percentage of working class population in each of these was determined. All blocks having 80 per cent or more working class population formed stratum 1. All blocks having between 10 to 80 per cent working class population constituted stratum 2. Blocks having less than 10 per cent working class population were excluded from the sampling frame. In stratum 1, blocks were arranged by chawks and within them by number of working class households and 4 independent samples of 12 blocks each were selected systematically with probability proportional to the number of working class households. In stratum 2, clusters of 2 blocks each were formed such that the blocks within a cluster were dissimilar with respect to the industries of the working class residents. 4 independent samples of 12 clusters each were selected systematically with probability proportional to the number of working class households.

44	Uttar Pradesh	Saharanpur	factory	cigarette, sugar, paper, textile	2	360	120

Sampling frame : The following areas were covered in the sampling frame — ward numbers 1, 2, 3, 4, 6, 10, 11, 13, 14 and 15 within Saharanpur town, and from the suburbs, Star Paper Mills quarters, and the villages Shukhpura Qadeem, Manak Man, Pinjora, Malikapur, Aujpur, Hasanpur, Nawada, Dabki.

Sampling method : Tenement sampling was adopted. The areas covered by the wards were divided into artificial blocks and these were clustered into groups of 4 or 5 each such that in each there was representation from workers in different industries and different areas, and the cluster population-sizes were equalised. 2 of the smallest villages were also grouped to form a sizeable cluster. The list of clusters and villages was arranged in decreasing order of their working class populations and 2 independent samples of 12 clusters or villages each were selected systematically with probability proportional to working class population.

srl. no.	state	centre	type	main industries	number of investigators	sample size for schedule	
						A	B
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
45	West Bengal	Asansol	factory	iron and steel, engineering	3	720	180

Sampling frame : The list of registered factories for the year ending 1957 in Raniganj municipal area, Ballavpur, Asansol municipality, Burnpur, Kulti, Barakar, Rupnarayanpur and Chittaranjan was the sampling frame. 31 factories were covered in all.

Sampling method : Payroll sampling was adopted. All factories having 2000 workers or more were included in stratum 1. The rest constituted stratum 2. Within each stratum, the factories were arranged in decreasing order of number of workers employed and 3 independent samples of 12 factories each were selected systematically with probability proportional to number of workers.

46	West Bengal	Calcutta	factory	not available during preliminary enquiry	4	720	240

Sampling frame : Bustees within Calcutta Corporation and Tollygunj excluding ward numbers 2, 5-8, 10-17, 22, 23 and 27 and including the labour areas in Garden Reach Municipality were covered by the sampling frame.

Sampling method : Tenement sampling was adopted. The bustees within Calcutta and the labour areas in Garden Reach were matched with the 1951 census blocks. The blocks within each ward were arranged in decreasing order of their sizes, size being measured by their working class populations and grouped into clusters of 3 blocks each to represent blocks of large, small and medium sizes and from different wards in each cluster. These clusters were arranged by their sizes and 4 independent samples of 12 clusters each were selected systematically, with probability proportional to their sizes.

47	West Bengal	Howrah	factory	jute, textile, oil, vanaspati, soap, engineering, plastics	5	1200	300

Sampling frame : The list of registered factories for the year ending December 1956, situated in Howrah, Bally and the industrial areas from Bauria to Fuleswar was the sampling frame. 542 factories were covered in all.

Sampling method : Payroll sampling was adopted. The factories employing 1000 or more workers constituted stratum 1. The rest of the factories constituted stratum 2. In stratum 1, the factories were arranged in decreasing order of number of workers and 5 independent samples of 12 factories each were selected systematically with probability proportional to the number of workers. In stratum 2, the factories were grouped to form clusters of 3 or 4 factories each such that each cluster was heterogeneous with respect to industry and size and all the factories in the cluster belonged to the same municipal area as far as possible. Five independent systematic samples of 12 clusters each were selected systematically, with probability proportional to the number of workers employed after arranging the clusters in decreasing order of the number of workers.

48	West Bengal	Raniganj	mining	coal	2	480	120

Sampling frame : The list of 199 registered mines in the areas (i) Raniganj — Bankura (ii) Raniganj — Birbhum and (iii) Raniganj-Burdwan, for the year ending 1956 was used as the sampling frame.

srl. no.	state	centre	type	main industries	number of investigators	sample size for schedules	
						A	B
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)

Sampling method : Payroll sampling was adopted The mines were classified as under Foreign and Indian management and by output classes. Mines having monthly output greater than 2500 tons, between 600 and 2500 tons and upto 600 tons respectively constituted the 3 output classes. Clusters of 4 mines each were formed such that each cluster had representation from different types of management, output classes and sizes with respect to employment. Attempts were made to equalize the cluster sizes. The clusters were arranged in increasing order of number of workers and 2 independent samples of 12 clusters each were selected pps systematically, size being number of workers employed.

49	West Bengal	Darjeeling	plantation	tea	2	480	120

Sampling frame : The list of 83 registered tea estates for the year 1955 situated in the following regions of Darjeeling district, known as the 'hill areas' was used as the sampling frame. Regions — Darjeeling West, Darjeeling East, Teesta Valley, Sonada, Rungbong, Kurseong, Mahanuddy, Tingling and Gorubathan.

Sampling method : Payroll sampling was adopted. Information on the number of workers employed in these estates in 1958 was available within each region, the estates were clustered into groups of 2 or 3 each such that each cluster was heterogeneous with respect to management (Indian or Foreign) and class (estates with area above 500 acres, between 300 and 500 acres, and below 300 acres formed classes A, B, and C respectively). The clusters were arranged in increasing order of number of workers employed and 2 independent samples of 12 clusters each were selected systematically with probability proportional to number of workers employed.

50	West Bengal	Jalpaiguri	plantation	tea	2	480	120

Sampling frame : The list of 153 registered tea gardens in the Dooars area of Jalpaiguri District for the year 1955 was used as the sampling frame.

Sampling method : Payroll sampling was adopted. Clusters of 2 or 3 gardens each were formed so that the gardens within a cluster were nearby and as different as possible with respect to management and class (as in Darjeeling). The clusters were arranged taking the same factors into consideration as in Darjeeling and 2 independent samples of 12 clusters each were selected systematically with probability proportional to the number of workers in the cluster.

Appendix 2

GOVERNMENT OF INDIA NATIONAL SAMPLE SURVEY

GENERAL INSTRUCTIONS ON THE PRELIMINARY SURVEY FOR THE FAMILY LIVING SURVEY OF WORKING CLASS (1958—59)

1. Introduction

1.1. On behalf of the Labour Bureau, the NSS will be conducting a Family Living Survey for the working class in 50 selected centres all over India, (32 factory centres, 10 plantation centres and 8 mining centres). The purpose of the survey is to estimate the weights to be used in computing cost of living index numbers for the working class in the next few years and to study their living conditions in these centres.

1.2. The survey is restricted to a section of the people, namely the working class households. These are the households of persons other than clerical and supervisory staff working in a factory, mine or plantation coming under the respective registration Acts, employed directly or through any agency (e.g. a contractor). The survey will cover a period of one full year so that information on seasonal variation in the expenditure pattern of the working class will be available. Separate cost of living index numbers are to be maintained for all the 50 centres and so separate estimates of weights are to be provided for each one of them. Knowledge of the conditions prevailing in the different centres is necessary to design the survey separately for each one of them, in the most efficient way. To get such knowledge it has been decided to conduct a preliminary survey in all these centres. During the survey, one phase of the frame collection will also be completed. The efficiency of the sampling design will depend to a great extent on the information collected in the preliminary survey. This information will also be helpful in reducing the operational difficulties of the main survey. In this preliminary survey, two questionnaires and one schedule will be canvassed in factory centres and one questionnaire in mining and plantation centres. *The investigating officers are requested to give any further information, besides that desired in the questionnaires and the schedule, which they consider to be useful and important in planning for the main survey.*

1.3. The following paragraphs describe the problems to be faced during the main survey and indicate how they may be solved with the help of the preliminary survey.

1.4. In the main survey information will be collected from working class households. These may be contacted in two ways. The first approach, tenement sampling, is to select some blocks of households in the centre, list the households in them and select the required number of working class households from each of them. The other, payroll sampling, is to sample some factories, mines or plantations in the centre and from their payrolls select the required number of workers. On the basis of the information collected for each of these approaches, it will be possible to decide as to which of them would be adopted.

1.5. The first problem is to define the centre. The list of specified centres give only their names and not their extent. Their boundaries have to be fixed in consultation with the officials of the Labour Department.

2. Factory centres

2.1. The working class households may not be evenly distributed over the entire area of the centre. There may be some areas having a high concentration of workers and some others having practically no labourers. Before sampling, it is essential that these two types of areas are marked out. Information about this should be had from some reliable quarters. Questionnaire 1.1 and the schedule will be used for this purpose.

2.2. Firstly, an idea of the wards which are important from the point of view of working class concentration can be had from the officials whose help is sought in fixing up the boundaries of the centre. He may also be able to define smaller localities within these wards having working class concentrations. The details about these localities are to be entered in the schedule. Separate sheets of the schedule should be used for each ward.

2.3. The following informants should also be approached for detailed information on each of the important wards:

(1) Labour Welfare Officers employed in the factories in the wards

(2) Trade Union Functionaries

(3) Municipal Authorities

(4) Doctors connected with Employees State Insurance

(5) Any other knowledgeable persons.

2.4. Having fixed the boundaries of the centre and noted information about the important wards as suggested above, the investigating officer should proceed as follows:

(a) He should ask the informants if there are any small pockets of working class localities in the remaining wards or adjoining areas which have been included in the centre. These may be labour quarters, colonies or bustees* etc.

(b) The informants should be asked to identify those wards in the centre which have practically no working class people inhabiting them. *Such wards may be safely excluded from the sampling frame, thus decreasing the field work and improving the design.*

(c) Lastly he will make an on-the-spot enquiry in all the important wards and in the working class localities in the rest of the centre. *The information collected in Questionnaire 1.1 and in the schedule will show where one should expect working class concentration.*

2.5. (a) During the spot enquiry the investigating officer will visit each and every circle in the important wards so as to ensure the completeness of the list of working class localities entered in the schedule. If the ward is not divided into circles — as may happen in some towns, similar information may be collected by any convenient sub-divisions of a ward, which are compact identifiable areas. The information about the boundaries, working class population etc. of the small localities obtained from different sources may be different. The investigating officer will decide about the final boundaries and finalise the other information of the localities and prepare a consolidated list on separate sheets of the schedule.

(b) During the spot enquiry the investigating officer will also determine the census blocks covering the important localities and enter them in the schedule. For this, he will need a copy of the National Register of Citizens (NRC). Some of these localities may be new colonies which do not have corresponding census blocks. The investigating officer will divide such colonies into well-defined artificial blocks, each having a population of about 750 persons, and enter their boundaries in the schedule.

2.6. The nature of the information collected in Questionnaire 1.1 will decide whether tenement sampling can be adopted for this centre. The other alternative is to sample from the payrolls of factories.

2.7. In order to examine the feasibility of payroll sampling, the investigating officer will collect certain broad information about the factories situated within the centre and about the payrolls and attendance registers maintained by them. Questionnaire 1.2 is meant for this purpose. The lines on which information is to be collected are indicated in the questionnaire itself.

2.8. A list of factories situated within the boundaries of the centre should be obtained from the municipal authorities. Once the names and addresses of such factories are obtained, relevant details about each of them, such as industry type, sector, management type, average number of workers, seasonal nature of production etc., can be obtained from the office of the Chief Inspector of Factories and/or municipal authorities. This information, it may be understood, is required to decide as to how factories are to be sampled.

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*In many cities there are slum areas which are recognised as the habitations of many of the working class people of the centre. These areas may be known as slums, bustees or chawls, and a list of them may be kept by the municipal or corporation authorities. These authorities should be approached by the investigator and a copy of the list with some supplementary information should be secured.

2.9. The investigating officer has to find out what information is available about each individual worker in the payrolls and attendance registers. For this, he will visit some selected factories and collect specimen copies of these documents. In selecting the factories, care should be taken as far as practicable to give representation to factories belonging to each (1) industry type, (2) sector, (3) management type and (4) size (big and small) as determined by the average number of workers.

2.10. The investigating officer will actually contact a few workers selected from the payrolls or attendance registers, and report how he contacted them and what difficulties he encountered while doing so.

2.11. In this connection it may be mentioned that in 18 of the factory centres, a survey on the level of living of middle class employees will also be taken up simultaneously. It is felt that in such centres, tenement sampling could be used and both the surveys can be integrated so that Questionnaire 1.2 need not be filled up. The list of the centres is given in the appendix.

3. MINING AND PLANTATION CENTRES

3.1. For a number of mining/plantation centres the Labour Bureau has already sent a list of mines/plantations which in the opinion of their officials should be covered during the survey. Where such a list is available, it will be sent to the investigating officer. He will get a confirmation locally if the list could serve as a definition of the centre. In case the officials suggest some changes, or if the list is not sent to the investigating officer, he will prepare a new list in consultation with the officials of the Labour Department.

3.2. Next, the investigating officer will try to procure a copy of some map showing the position of the mines/plantations, their names and the names of the villages. Even if the map is not available, he will try to get a list of towns and villages within 5 miles of the mines/plantations of the centre.

3.3. He will get some information about each of the mines/plantations as desired in Questionnaire 2. If the list of mines/plantations is not long, and if it is possible, the investigating officer will visit each one of the mines/plantations to get information about payrolls and attendance registers as well as about the quarters provided by the management to the workers. If the list is long, he will visit at least one mine/plantation of each type for the information. The nature of information to be collected is indicated in the questionnaire.

3.4. The investigating officer will actually contact a few workers selected from the payroll or attendance registers and report how he contacted them and what difficulties he encountered while doing so.

4. DESPATCHING OF THE QUESTIONNAIRES AND THE SCHEDULES

4.1. The questionnaires and the schedules (including working sheets) should be filled in duplicate and the originals should be sent to the Indian Statistical Institute, Calcutta. The duplicate copies should be kept at the block headquarters.

FAMILY LIVING SURVEYS

LIST OF CENTRES TO BE COVERED FOR THE WORKING CLASS FAMILY LIVING SURVEY

state	district	centre
	factory centres	
Assam	Lakhimpur	1. Digboi (Tinsukia)
Bihar	Singhbhum	2. Jamshedpur
	Monghyr	3. Monghyr-Jamalpur
Bombay	Bombay	*4. Bombay
	Ahmedabad	*5. Ahmedabad
	Nagpur	*6. Nagpur
	Gohelwad	7. Bhavnagar
	Sholapur	8. Sholapur
Madhya Pradesh	Bhopal	*9. Bhopal
	Indore	*10. Indore
	Gwalior	*11. Gwalior
Madras	Madras	*12. Madras
	Madurai	*13. Madurai
	Coimbatore	14. Coimbatore
Andhra Pradesh	Guntur	15. Guntur
	Hyderabad	*16. Hyderabad
Orissa	Sambalpur	*17. Sambalpur
Uttar Pradesh	Kanpur	*18. Kanpur
	Banaras	19. Banaras
	Saharanpur	20. Saharanpur
West Bengal	Calcutta	*21. Calcutta
	Howrah	22. Howrah
	Burdwan	23. Asansol
Mysore	Bangalore	*24. Bangalore
Kerala	Kottayam	25. Alwaye
	Alleppey	26. Alleppey
Punjab	Amritsar	*27. Amritsar
	Ludhiana	28. Jamunanagar
Rajasthan	Jaipur	*29. Jaipur
	Ajmer	*30. Ajmer
Delhi	Delhi	*31. Delhi
Jammu and Kashmir	Srinagar	*31. Srinagar
	mining (M) and plantation (P) centres	
Assam	Cachar	1. Labac (P)
	Darrang	2. Rangapara (P)
	Sibsagar	3. Mariani (P)
	Lakhimpur	4. Doom Dooma (P)
Bihar	Manbhum	5. Jharia (M)
	Hazaribagh	6. Kodarma (M)
	Singhbhum	7. Noamundi (M)
Madhya Pradesh	Balaghat	8. Balaghat (M)
Andhra Pradesh	Nellore	9. Gudur (M)
Madras	Nilgiris	10. Coonoor (P)
Orissa	Keonjhargarh	11. Barbil (M)
West Bengal	Burdwan	12. Ranigunj (M)
	Darjeeling	13. Darjeeling (P)
	Jalpaiguri	14. Jalpaiguri (P)
Mysore	Kolar	15. Kolar G. F. (M)
	Chikmaglur	16. Chikmaglur (P)
	Coorg	17. Ammathi (P)
Kerala	Kottayam	18. Mundakkayam (P)

*Centre for the Middle Class Survey also.

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GOVERNMENT OF INDIA NATIONAL SAMPLE SURVEY
Family Living Survey of Working Class in Selected Centres (1958-59)
Preliminary Survey (Frame Collection) Schedule for Listing Localities (for factory centres only)

name of centre :

name and/or number of ward .

boundaries of ward :

serial number of locality	name, designation, and address of informant	name and boundaries of locality	percentage of workers belonging to different industries		percentage of workers coming from different states		approx. no. of factory workers including dependants	total population of locality	identification of the blocks covering the locality		remarks
			name of industry	%	name of state	%			circle	census block number or boundaries of artificial blocks	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)

* delete whichever is inapplicable

1. name of the investigating officer

2. period of survey

3. signature

GOVERNMENT OF INDIA NATIONAL SAMPLE SURVEY

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FAMILY LIVING SURVEY OF WORKING CLASS IN SELECTED CENTRES : 1958-59
PRELIMINARY SURVEY : QUESTIONNAIRE—1.1 (FOR ALL FACTORY CENTRES)

A. Name of the centre :—

B. Names, designations and addresses of the officials of the labour department contacted to obtain information on the boundaries of the centre :—

C. List down all the wards in the municipality or corporation with their boundaries in Table 1 and fill it up in consultation with the officials. If information in column (4) is not available, write N.A. For filling up column (5) of the table, a ward will be considered as important if the official considers it important for the survey because it has working class concentration ; a ward will be considered unimportant if, in the opinion of the official, it can be safely excluded from the coverage of the survey. *There may be wards which are neither important nor unimportant. Against the names of such mixed wards put a '×' mark.*

TABLE 1

srl. no.	name of ward	boundaries of ward	number of factory workers	important-1, unimportant-2	reasons for exclusion of unimportant wards
(1)	(2)	(3)	(4)	(5)	(6)
total	×	×	×	×	×

*delete whichever is inapplicable.

D. Get answers from the official (s) for the following questions :

1. (i) What percentage of working class population in the centre (factory workers) will be excluded if we cover only the *important* wards in the survey ?

Answer :—

(ii) What percentage of the working class population of the centre will be excluded if we *do not cover* the *unimportant* wards in the survey ? (i.e. if we cover the important *and* mixed wards)

Answer :—

2. (a) Outside the municipal or corporation area of the centre, are there any adjoining areas (villages, towns, parts of villages or towns, colonies, or any such compact identifiable areas) having labour concentrations ?

Yes / No. (Circle the answer).

If the answer is 'no', questions 2b, 2c, and 3 need not be asked.

If the answer is 'yes', ask

(b) Do you consider it necessary that they should also be covered by this survey ?

Yes / No. (Circle the answer).

If the answer is 'no', question 2c, need not be asked.

If the answer is 'yes', ask further.

(c) (i) By what names are these areas identified ?

(ii) What is the number of factory workers in each of them ? Enter the answers in the following table :

TABLE 2

srl. no.	name of the area	boundaries of the area	number of factory workers
total	×	×	×

3. If the answer to question 2(b) is 'no' ask the following question :
   Why do you think that they can be excluded from the coverage of the survey ?
   Record the explanation given in the space below.

E. Is a list of bustees, chawls, slums or any such well defined areas recognised as working class localities in the centre available with the corporation or municipal authorities ? Yes/No. (Circle the answers).

If yes, enter the list in the schedule with the information asked for there. This list of bustees may be helpful in getting answers to questions F(1 and 2).

F. Put the following questions to the above labour official (s) and the other sources mentioned in paragraph 2.3 of the general instructions and fill up the schedule whenever answer is 'yes'.

1. Is it possible to mark out, within the important wards listed in Table 1, smaller localities which contain working class concentrations (may be working class quarters, colonies etc.) ?
2. Is it possible to mark out within the wards of the centre, marked '×' in column (5) of Table 1, working class concentrations in small localities which can be defined by identifiable boundaries ?
3. If the answer to question 2(b) is 'yes', ask the following question also. Is it possible to give a list of small localities having working class concentration within these adjoining areas ?

G. Record any other relevant information which in your opinion is sufficiently important, on the back of this sheet.

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1. Name of Investigating Officer..
2. Period of the preliminary survey..
3. Date of despatch...
4. Signature...

....

GOVERNMENT OF INDIA NATIONAL SAMPLE SURVEY

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FAMILY LIVING SURVEY OF WORKING CLASS IN SELECTED CENTRES : 1958-59
PRELIMINARY SURVEY : QUESTIONNAIRE—1.2

(for factory centres excluding those which are centres
for the middle class survey also)

A. Name of the Centre :—

B. Names, designations and addresses of persons contacted to get a list of registered factories in the centre. (Inspector of factories, and/or municipal authorities and/or other sources (specify)) :

C. If a list of registered factories for the centre is available, copy down the information about these factories in the following table.

FAMILY LIVING SURVEYS

TABLE 1. LIST OF FACTORIES IN............(NAME OF THE CENTRE) WITH REFERENCE TO THE YEAR ENDING.............

srl. no.	name of factory	address of factory	industry type	months during which there is production	sector : public, private/joint	management : Indian, foreign	average number of workers employed
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
total	×	×	×	×	×	×	×

D. Visit one factory of each major industry type. As far as possible, try to select the factories to be visited so as to represent factories of different ownership and management types as well as factories of different sizes (number employed may be an indication of the size).

1. Copy down one specimen page each from the attendance register and payrolls of each one of the visited factories. Attach these along with this questionnaire.

2. Name and address of the factory :—

3. Regarding payrolls obtain information on the following points :

(a) How the payrolls are kept (tick those which are applicable)
- (i) separately for different sections
- (ii) separately for skilled and unskilled workers
- (iii) separately for each category like casual, badli, temporary and permanent workers
- (iv) in any other manner (*to be specified*)

(b) What is the system of assigning roll numbers or serial numbers to the workers in the payrolls. (tick those which are applicable).
- (i) no system of numbering in practice
- (ii) a continuous serial number for the factory as a whole
- (iii) separate system of numbering for different sections or departments
- (iv) separate system of numbering for different categories like casual etc.
- (v) separate system of numbering for skilled and unskilled workers
- (vi) separate system of numbering for workers in different shifts
- (vii) any other system (*to be specified*).

(c) (i) Are the addresses of the workers available in the office of the factory ? Yes / No. (Circle the answer)

(ii) Are the addresses given complete (so that the workers can be contacted by means of these addresses alone) ? Yes / No. (Circle the answer).

(iii) Are the addresses up-to-date or at least fairly so ?
Yes/No. (Circle the answer). If the answer is No, will it be practicable to collect the address of any factory employee at the time of the main survey without difficulty or delay, and how ?

E. Notes on E (1, 2, 3, 4) may be written on the back sheet.

1. Select 2 or 3 workers (living in different areas) from the payrolls or attendance register of each factory visited and try to contact the selected workers. Note down all the difficulties encountered in contacting them.

2. Also try to ascertain the extent to which the workers would co-operate in filling up the Schedules of the Main Survey.

3. Note down the extent to which the management of the factories are willing to co-operate.

4. Record any other relevant information which in your opinion is sufficiently important.

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1. Name of the Investigating Officer ....
2. Period of Survey..
3. Date of despatch..
4. Signature ....

GOVERNMENT OF INDIA NATIONAL SAMPLE SURVEY ORIGINAL*/DUPLICATE

FAMILY LIVING SURVEY OF WORKING CLASS IN SELECTED CENTRES : 1958-59
PRELIMINARY SURVEY : QUESTIONNAIRE 2 (FOR MINING/PLANTATION CENTRES ONLY)

A. Name of centre :—

B. Names, designations, and addresses of the official (s) of the labour department contacted for obtaining information on the boundaries of the centre.

C. Show the copy of the list of mines/plantations (sent to ISI by the Labour Bureau) supplied herewith to the official (s) and ask if they want to make any changes in the list for the final definition of the centre. Prepare a final list as decided by the officials and attach it to the questionnaire.

D. Is it possible to get a map showing the location and other identification details of the mines/plantations within the centre ?

Yes / No. (Circle the answer)

If the map is available attach it with this questionnaire. If that is not possible at least get the names of all the towns and villages within 5 miles of mines/plantations listed above where the working class population is predominant. Attach this list to the questionnaire.

E. Names, designations and addresses of authorities consulted for getting the information entered in the following table.

TABLE 1. DETAILS REGARDING THE REGISTERED MINES/PLANTATIONS WITHIN THE CENTRE

srl. no.	name and other identification particulars of mine/plantation	distance (in miles) from the head-quarters of the centre	number of workers	sector : public, private, joint	management : Indian, foreign	** class	proportion of workers living in quarters provided by the management	remarks on the seasonal nature of labour employed
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

* delete whichever is inapplicable.

** The classifications may be for mines by output and for plantations by area or it may be on any other basis. Give a footnote regarding the basis of classification.

F. 1. Visit one mine/plantation of each type (sector, management and class). Copy down one specimen page each of the attendance register and payroll of each one of the visited mines/plantations. Attach these along with this questionnaire.

2. Name and address of the mine/plantation.

3. Regarding payrolls obtain information on the following points :

(a) How the payrolls are kept (tick those which are applicable)

(i) separately for different sections

(ii) separately for skilled and unskilled workers

(iii) separately for each category of workers like casual, badli, temporary, permanent etc.

(iv) in any other manner (*to be specified*)

(b) What is the system of assigning roll numbers or serial numbers to the workers in the payrolls. (tick those which are applicable).

- (i) no system of numbering in practice
- (ii) a continuous serial number for the mine/plantation as a whole
- (iii) separate system of numbering for different sections or departments
- (iv) separate system of numbering for each category of workers like permanent, casual etc.
- (v) separate system of numbering for skilled and unskilled workers
- (vi) separate system of numbering for workers in different shifts
- (vii) any other system (*to be specified*)

(c) (i) Are the addresses of the workers available in the office of the mine/plantation :

Yes / No. (Circle the answer).

(ii) Are the addresses given complete (so that the workers can be contacted by means of these addresses alone) ?

Yes / No. (Circle the answer).

G. Notes on G (1, 2, 3 and 4) may be written on the back of the sheet.

1. Select 2 or 3 workers (living in different areas) from the payrolls or attendance register of each mine/plantation visited and try to contact the selected workers. Note down all the difficulties encountered in contacting them.
2. Also try to ascertain the extent to which the workers would cooperate in filling up the schedules of the Main Survey.
3. Note down the extent to which the management of the mines/plantations are willing to cooperate.
4. Record any other relevant information which, in your opinion is sufficiently important.

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1. Name of the Investigating Officer...
2. Period of .Survey...
3. Date of despatch...
4. Signature...

Memo no. 5040/NSS

Indian Statistical Institute,
203, Barrackpore Trunk Road,
Calcutta-35.

8 January 1958

MEMORANDUM

SUBJECT : WORKING CLASS FAMILY LIVING SURVEY, 1958-59—PRELIMINARY SURVEY

The following clarifications are given in view of certain questions raised :

GENERAL

1. For the factory centres (which are not centres for the middle class survey) Questionnaires 1.1 and 1.2 are meant primarily for deciding whether tenement sampling or payroll sampling is to be adopted. If local study and enquiry reveals to the Investigating Officer that one of the two methods is to be preferred from the point of view of completeness, ease of collection of the sampling frame, practical convenience etc., only the corresponding questionnaire (1.1 if tenement sampling is preferred and 1.2 if payroll) is to be filled in. He should, of course, write a note on how he decided between the two methods.

If, however, this quick appraisal does not help him in taking a decision, he should fill in both the questionnaires.

For example, in a particular centre there may be very few factories and he may be informed that the payrolls and addresses of their workers are kept at the factories but the workers live scattered over a large area in the centre. In this case, it would seem that payroll sampling may be the preferable method and Questionnaire 1.2 only need be filled in.

On the contrary, if factory payrolls are ill-kept or the workers cannot be easily contacted with the help of the records kept there, then evidently tenement sampling should be adopted. Concentration of labour habitations in the centre will of course facilitate this method.

2. It is suggested that only the mines/plantations which commonly go by the name of the selected centre in respect of their location should be enlisted.

3. Regarding paragraph 3.2 of the General Instructions it may be noted that the intention is to list all the towns and villages in which the population working in the mines/plantations of the centre is predominant. But it is expected that, in general, it would not be necessary to include areas which are not within a distance of five miles from any mine/plantation. Five miles is only indicative of the range and need not be taken literally.

4. Regarding paragraph 2.5 (a) of the General Instructions/further guidance in respect of sub-division of the wards in towns where they have not been divided into circles seems necessary on the following lines :—

(i) It will be better to identify the artificial blocks by the names of the roads, lanes etc.

(ii) The blocks of quarters with quarter number, important land-marks like shops, temples and wells etc. may also be used for fixing the boundaries.

5. The filled-in questionnaires and schedules should be sent to Officer-in-charge, National Sample Survey, Indian Statistical Institute.

QUESTIONNAIRE 1.2

1. Regarding the collection of some information about the factories it is to be noted that only the list of factories is to be collected from the municipal authorities (or from the Inspector of Factories if it is not available there) which has been made clear in the instructions. The details could be collected from the labour officers, factory or wage inspectors in the centre and not necessarily from the Chief Inspector of Factories.

2. Table 1 : It is suggested that information in the various columns in Table 1 of the Questionnaire 1.2 should be collected with reference to the calendar year 1956 or 1957 whichever is readily available. The reference year is to be indicated at the heading of the table.

3. Table 1, col. (4) : If a factory manufactures more than one product, the most important product would determine its industry type.

4. Table 1, col. (5) : If a factory works for only a few months during the year, it will be futile to visit it for detailed enquiry when it is not working. Hence this information.

5. Paragraph D : As regards the definition of small and big factories, it is to be noted that a uniform definition for all centres cannot be given. The Investigating Officer should go through the list of factories giving the number of workers and decide himself which of the factories can reasonably be considered as big.

SCHEDULE

1. The information in cols. 4 to 8 of the Preliminary Survey (Frame Collection) Schedule is not intended to be collected by contacting all the households, as this would involve a heavy work-load. It is suggested that some knowledgeable persons in the localities are to be consulted in filling up these columns. If the Investigating Officer has reason to believe that the figures so reported are not correct, this should clearly be mentioned in col. (12) of the schedule meant for 'remarks'.

Appendix 3

EXTRACT FROM THE FACTORY ACT (1948), MINE ACT (1952) AND PLANTATION ACT (1951)

The word "*factory*" under the Act means any premises including the precincts thereon :

(i) whereon 10 or more workers are working or were working on any day of the preceding 12 months, and in any part of which a manufacturing process is being carried on with the aid of power or is ordinarily carried on or

(ii) whereon 20 or more workers are working, or were working on any day of the preceding 12 months, and in any part of which a manufacturing process is being carried on with the aid of power, or is ordinarily so carried on.

Besides, the establishments coming under Section 85 (A) of the Factories Act in any State should also be included as "factory." By "manufacturing process" is meant any process for :

(i) making, altering, preparing, ornamenting, finishing, packing, oiling, washing, cleaning, breaking up, demolishing or otherwise treating or adopting any article or substance with a view to its use, sale, transport, delivery or disposal ; or

(ii) pumping oil, water or sewage ; or

(iii) generating, transforming or transmitting power ; or

(iv) composing types for printing, printing by letter press, lithography, photogravure or other similar process or book binding ; or

(v) constructing, repairing, refitting, finishing or breaking up ships or vessels.

"*Mine*" means any excavation where any operation for the purpose of searching for or obtaining minerals has been or is being carried on, and includes :

(i) every shaft in the course of being sunk ;

(ii) every level and inclined plane in the course of being driven ;

(iii) all shafts, levels, planes, machineries, works, tramways and sidings, whether above or below ground, in or adjacent to, and belonging to, the mine ;

(iv) any workshop situated within the precincts of the mine and under the same management and used solely for purposes connected with that mine or a number of mines under the same management ;

(v) any power station for supplying electricity solely for the purpose of working the mine, or any group of mines ; and

(vi) unless exempted by the Central Government by notification in the Official Gazette, any premises or part thereof on which any process ancillary to the getting, dressing or preparation for sale of minerals or of coke is being carried on.

"*Plantation*" means any land used or intended to be used for growing tea, coffee, rubber, or cinchona which admeasures 25 acres or more and whereon 30 or more persons are employed, or were employed on any day of the preceding 12 months, and in any State where the provisions of this Act have been applied by Notification under Sub-section (4) of Section (1) to any other class of plantation means also any land used or intended to be used for growing plant mentioned in such notification and whereon 30 or more persons are employed or were employed on any day of the preceding 12 months.

Appendix 4

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GOVERNMENT OF INDIA NATIONAL SAMPLE SURVEY : 1958-59
MIDDLE CLASS FAMILY LIVING SURVEY
Schedule L (m) : List of families (main sheet)

[1] identification particulars of block

1. state.................................. ☐ 2. centre.................. ☐ 3. s.u. 1(sr. no.) ☐

4. month of enquiry........................ 5. stratum ☐ 6. sub-sample ☐

7. block boundaries..

....

[2] particulars of investigation, inspection and scrutiny

	investigator	inspector	field scrutiniser
1. name			
2. roll number			
3. date of survey/inspection/scrutiny			×
4. date of receipt/despatch			
5. number of scrutiny sheets attached		×	
6. signature			

[3] investigator's time record · dates covered from....... ....to.........................

sr. no.	type of work	number of hours (0.0) spent							
		sunday	monday	tuesday	wednesday	thursday	friday	saturday	total
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1.	journey from hq. to centre								
2.	" from centre to centre								
3.	" from camp to block and back								
4.	listing of families								
5.	selection of sample families								
6.	copying schedule L(m)								
7.	other office work								
8.	journey from centre to hq.								
9.	total								

[4] remarks by investigator

[5] comments by inspector

* delete whichever is inapplicable

E.P. 1784—15.5.58—15,000

Sch. L (m)—2

[6] list of families and record of selection

house number	family serial number	name of head of family	source of major income for the family				family type (a)	family size	expenditure class (b)	state of origin of the head of family		sampling serial number for middle class employees families						
			manual		non-manual													
			factory/mine/plantation	others	employee in non-agricultural sector	others				code : major-1 minor-2	description	11	12	13	23	22	21	order of selection
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)

code numbers :- (a) family type working class-1, middle class employee-2, others-3.
(b) expenditure class for middle class employees families below Rs. 150-1, Rs 150 to below Rs. 300-2, Rs 300 and above-3

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GOVERNMENT OF INDIA NATIONAL SAMPLE SURVEY : 1958-59
WORKING CLASS FAMILY LIVING SURVEY
Schedule L (w) : List of families (main sheet)

[1] identification particulars of block

1. state.................................. ☐ 2 centre................................... ☐ 3. s.u.I (sr. no.) ☐
4. month of enquiry........................ 5 stratum ☐ 6. sub-sample. ☐
7. block boundaries...
....
....

[2] particulars of investigation, inspection and scrutiny

	investigator	inspector	field scrutiniser
1. name			
2. roll number			
3. date of survey/inspection/scrutiny			×
4. date of receipt/despatch			
5. number of scrutiny sheets attached	×	×	
6. signature			

[3] investigator's time record : dates covered from .... to ....

sr. no.	type of work	number of hours (0.0) spent							
		sunday	monday	tuesday	wednesday	thursday	friday	saturday	total
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1.	journey from hq. to centre								
2.	" from centre to centre								
3.	" from camp to block and back								
4.	listing of families								
5.	selection of sample families								
6.	copying schedule L(w)								
7.	other office work								
8.	journey from centre to hq.								
9.	total								

[4] remarks by investigator

[5] comments by inspector

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* delete whichever is inapplicable

E.P. 1748—15.5.58—70 0

Schedule L (w) : List of families (auxiliary sheet)

identification particulars of block

1 state.............................. ... ..

2 centre..... .. ..

3. s.u.I (sr. no.)

4 month of enquiry ....

5 stratum.. . . ..

6. sub-sample

[6] list of families and order of selection

			source of major income for the family							state of origin of the head of family		sampling serial number for working class families								
			manual		non-manual															
house number	family serial number	name of head of family	factory/mine/plantation	others	employee in non-agricultural sector	others	family type (a)	family size	expenditure class (b)	code major-1 minor-2	description	111	112	122	121	221	222	212	211	order of selection
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)

code numbers : (a) family type : working class–1, middle class employee–2, others–3
(b) expenditure class : (i) for working class families below Rs. 60–1, Rs. 60 and above–2,
(ii) for middle class employees families below Rs. 150–1 Rs.150 to below Rs. 300–2, Rs 300 and above–3.

F.P 1784—15.5.58—19000

ORIGINAL*
DUPLICATE

GOVERNMENT OF INDIA NATIONAL SAMPLE SURVEY : 1958-59
Working Class Family Living Survey
Schedule P : Selection of Workers

[1] identification particulars of factory/mine/plantation*

1. zone-state-centre		2. centre	5. sample serial no.	
3. name of factory/m/pl*			6. month	
4. address of factory/m/pl*			7. stratum	
....			8. sub-sample	

[2] particulars of investigation, inspection and scrutiny

sr. no.	item	investigator	inspector	field scrutiniser
1.	name			
2.	roll number			
3.	date of survey/inspection/scrutiny			×
4.	date of receipt despatch			
5.	no. of scrutiny sheets attached	×	×	
6.	signature			

[3] investigator's time record dates of investigation, from ....to.................

sr. no	operation	time in hours (0.0) for the operation on							total
		Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1.	journey from headquarters to camp								
2.	journey from camp to camp								
3.	journey from camp to factory								
4.	journey from factory to factory								
5.	journey from factory to camp								
6.	journey from camp to headquarters								
7.	sub-total : 1 to 6								
8.	procuring registers								
9.	filling up block 6								
10.	obtaining addresses and contacting workers								
11.	sub-total : 8 to 10								
12.	others								
13.	total : 7+11+12								

[4] remarks by investigator

[5] comments by inspector

* delete whichever is inapplicable

E.P. 1784—15.5.55—11,000

sch. P—2

[6] particulars of sampling								
1 exact no. of workers N :				2. interval I			3. random start R :	
sr. no.	description of register	highest sr. no. in register	sr nos of workers, non manual or no longer working	actual no. of workers	cumulative total of col (4)	systematically selected nos.	col. (6)—cum. total in col. (5) against previous register	serial nos. of selected workers*
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)

---

* for filling in this column, refer to para. 8.13 of instructions on schedule P.

sch. P—3

[7] list of selected workers

sr. no.	worker's no. in register	name of worker	identification particulars as available in register	address obtained by contacting worker	selected for schedule
(0)	(1)	(2)	(3)	(4)	(5)

BOOK REVIEWS

Characteristic Functions : By E. Lukacs, Charles Griffin & Co. Ltd., London, 1960.

The properties of characteristic functions (that is, the Fourier transforms of distribution functions) are briefly studied in several English text books on Probability Theory and Mathematical Statistics : such as, *Random Variables and Probability Distributions* (Cambridge University Press, 1937) and *Mathematical Methods of Statistics* (Princeton University Press, 1946) by H. Cramér and *Probability Theory* (D. Van Nostrand and Company, 1955) by M. Loève. The present book gives an elaborate account of the theory of characteristic functions. The first four chapters deal with the elementary properties of characteristic functions : such as, the relations between the derivatives of the characteristic function and the moments of the corresponding distribution ; the uniqueness, inversion, convolution and continuity theorems and necessary and sufficient conditions for a function to be a characteristic function. Chapter 5 gives an account of the theory of infinitely divisible distributions and, in particular, the theory of stable distributions. The properties of analytic characteristic functions (that is, the characteristic functions which are regular in a circle about the origin) are exclusively dealt with in Chapter 7. The theory of decomposition of probability distributions (which is commonly known as the arithmetic of distribution functions) is discussed in two chapters—factorization theorems of a general nature are treated in Chapter 6, while those for the special case of analytic characteristic functions are given in Chapter 8. Finally in Chapter 9, the mixtures of distribution functions and also some transformations of characteristic functions are discussed. In various chapters many important results are discussed which are published in only French and Russian journals and are not easily accessible to the English readers.

The book will be quite useful as a text for a specialised course on characteristic functions.

R. G. Laha

The Advanced Theory of Statistics, Volume 2—Inference and Relationship : By M. G. Kendall and A. Stuart, Charles Griffin & Co. Ltd., London, 1961.

This is volume two of the extended version that replaces the two volumes on *The Advanced Theory of Statistics* by M. G. Kendall. This volume contains eighteen chapters on topics relating to estimation, testing hypothesis, confidence and fiducial intervals, distribution-free methods, sequential analysis, regression analysis : linear regression, simple, partial and multiple correlations, and statistical relationship : functional and structural. There is a copious number of examples at the end of each chapter. The list of references is quite exhaustive. The statistical tables in common use are reproduced at the end of the book. The subject matter of the book occupies about 600 pages.

This volume covers in a detailed fashion the subject matter that falls under its chapter titles. This book has the great merit of being the only and single book of such a wide coverage and is unlikely to be surpassed for a long time. We, therefore, undertake to comment only on the peculiarities of style and emphasis, obscurities and mistakes found in the book.

In style and emphasis this volume does not differ from the earlier volumes of *The Advanced Theory of Statistics* by M. G. Kendall. The authors spurn the decision theory approach to inference, for instance in Section 34.41. The authors' interest in nonparametric methods is very narrow. Nonparametric tests are proposed for problems where only the hypothesis is widened and the alternatives restricted to be normal.

Proofs which are heuristic in their nature are not mentioned to be so : to give an example, the heuristic proof due to Fisher of the limiting χ^2 distribution of the χ^2 goodness of fit statistic is presented in Section 30.10.

It is not mentioned that this proof is heuristic and why, but, as an after thought, the section ends with the sentence 'a more rigorous proof is found in Cramér (1946).' The exposition on sufficient statistics is not satisfactory. In fact the illustration in example 17.16, of the factorisation theorem for a sufficient statistic, is confusing.

Our serious criticisms are limited to Chapters 18 and 25. Section 18.10 gives a 'simplified form of Wald's proof' of the consistency of the maximum likelihood estimate (m. l. e.). The m. l. e. $\hat{\theta}$ is defined, in the usual notation, by

$$L(x, \hat{\theta}) \geqslant (L(x, \theta) \quad \text{for all } \theta$$

and so in particular

$$L(x, \hat{\theta}) \geqslant L(x, \theta_0) \qquad \dots \quad (18.20)$$

holds. The authors first establish that for each $\theta^* \neq \theta_0$ (i.e. whenever $L(x, \theta^*) \not\equiv L(x, \theta_0)$)

$$\lim_{n \to \infty} \text{prob}_{\theta_0} \{\log L(x, \theta^*) < \log L(x, \theta_0)\} = 1 \qquad \dots \quad (18.21)$$

and state that from (18.20) and (18.21) it follows that

$$\lim_{n \to \infty} \text{prob}_{\theta_0} \{\hat{\theta} = \theta_0\} = 1 \qquad \dots \quad (18.22)$$

It is trivial to see that no form of consistency of $\hat{\theta}$ follows from (18.20) and (18.21) and thus the proof of the consistency of the m. l. e. is invalid.

Apart from this, relation (18.22) comes as a shock to us. This defines a new form of consistency which is unfortunately rarely found in practice. We could not drop (18.22) as some kind of misprint for we found similar relationships occurring again, for example in (18.24), (30.98).

Relation (18.23) reads

$$\frac{1}{n}\left[\frac{\partial^2}{\partial \theta^2} L(x, \theta)\right]_{\theta=\hat{\theta}} \xrightarrow[n \to \infty]{} \frac{1}{n}\left[\frac{\partial^2}{\partial \theta^2} L(x, \theta)\right]_{\theta=\theta_0} \qquad \dots \quad (18.23)$$

and the meaning to be imparted to it is not apparent.

In Section 18.12 it has been asserted that a local maximum of $L(x, \theta)$ is consistent for θ_0 which does not follow from any previous results in the book.

Chapter 25 deals with the comparison of tests. The notations are confusing since the dependence on n and θ, which needs to be displayed in the demonstrations, is suppressed in this chapter. The proof in Section 25.5 of the expression (25.27) for the Pitman's efficiency of two tests is not valid without the following extra assumption : with the notations of the text, t_i has an asymptotically normal distribution under $\theta_{i,\,n} = \theta_0 + \frac{k_i}{n^{\delta_i}}$ with asymptotic mean $E(t_i \mid \theta_{i,\,n})$ and asymptotic variance var $(t_i \mid \theta_{i,\,n})$ as $n \to \infty$, $i = 1, 2$. In Chapter 31 we find a discussion of the efficiencies of distribution-free tests. The excellence of this discussion is marred by the omission of any verification of this important assumption.

Sections 25.8 and 25.9 allegedly establish a relationship between Pitman's efficiency and the limit of the ratio of the non-vanishing derivative (at the null hypothesis) of minimum order (usually the first or second) of the power function of the two tests. The arguments are faulty and the results are not valid. This is so because the authors argue somewhat as follows : if $a_n(\theta) - b_n(\theta)$ and $\alpha_n(\theta) - \beta_n(\theta)$ tend to 0 as $n \to \infty$, then $a_n'(\theta_0) - b_n'(\theta_0) \to 0$ and $\alpha_n'(\theta_0) - \beta_n'(\theta_0) \to 0$; and again $\frac{a_n'(\theta_0)}{\alpha_n'(\theta_0)} - \frac{b_n'(\theta_0)}{\beta_n'(\theta_0)} \to 0$.

The authors deserve to be praised for making available an encyclopedic collection of material on inference and regression theories in a single book. This book is an indispensible reference book to any statistician. However, it would require a careful reader to overcome the difficulties of style and emphasis of exposition in the book.

J. Sethuraman

Stochastic Service Systems : By John Riordan, Bell Telephone Laboratories Inc., John Wiley & Sons, 1962.

This book, the first of *the SIAM series in Applied mathematics* brought out by the Society for Industrial and Applied mathematics (USA) is a very welcome addition to the growing literature in the subject of operations research. The book is of interest also to statisticians, probabilists, applied mathematicians, econometricians and industrial engineers and deserves a place in every modern library of mathematics and statistics.

Professor Riordan is the author of another book entitled *The Elements of Combinatorial Analysis*, also published by John Wiley & Sons. His power and gifts of exposition are enviable and in one hundred and thirty-three pages, he has given a connected account of the mathematical models of service systems in which demands for service and the services supplied are of a stochastic nature. The subject has its origin in "Telephony" and has many things in common with both *queueing theory* and *traffic probability theory*. The mathematical tools used are chiefly generating functions, Laplace Transforms and differential equations. The emphasis is on practical methods of dealing with the systems.

After an introductory Chapter I dealing with the physical situations and a simple Chapter II dealing with input and service distributions, the main subject is treated in the last four chapters entitled "The simplest traffic system," "Single-server systems," "Many-server systems" and "Traffic measurements." A selected list of about one hundred references is given at the end of the book.

Though most of the results in the book are well known, there are a few new results : (1) the determination of transitional probabilities in the simplest traffic system when initial point is not an arrival epoch, (2) the stationary delay distribution for last-come first-served service, (3) a new derivation due to S. O. Rice of the results for simplest loss and delay systems, and (4) a few formulae for moments of certain measures of effectiveness.

The book has benefited by criticisms by famous workers in the field like S. O. Rice, V. E. Benes, R. Pyke, L. Takacs and R. I. Wilkinson.

We close this review with a summary of the last four chapters.

The simplest traffic system dealt with in Chapter III is one with an infinite number of servers. After deriving the transition probabilities for Poisson input and exponential service case, the author gives the distribution of sum of service times of all demands arriving in a given time interval. Then he considers the case of limited traffic sources and goes on to the case of recurrent input using a method of Takacs (1959). Finally, he derives the integral equation of Palm (1943) for the distribution of the overflow traffic and also other results on overflow rates and sizes.

In Chapter IV dealing with single-server systems, *loss systems* (those in which demands not served and dismissed) are considered first. The size of the loss is the variable of interest and results are obtained for Poisson or recurrent input and exponential service. Next, *delay systems* are discussed. The stationary distribution of waiting time and queue-length for the delay system with Poisson input and general service time are obtained by the method of supplementary variables due to D. R. Cox (1955). The results of Lindley (1952) for the general case are then derived. Then follows the results of Pollaczek (1959) in the case of a *connection delay*, and those of Takacs (1955) on the important concept of *virtual waiting time*. Next, the stationary distribution of the length of *busy period*, the closely related delay distribution for last-come first-served service and some allied results are derived. After a brief discussion of *priority service*, the chapter ends with some expressions for *stationary averages* for combined loss and delay systems.

Chapter V dealing with many-server systems begins with the simplest loss system with extensions to recurrent input and *the effect of retrials* (dismissed demands which try again). Next are considered combined delay and loss systems. The *pure delay system* is then given as the limit for increasing capacity, serving as an introduction to the important results of Karlin and McGregor (1958). Certain results on delay distributions by Palm (1946) and Vaulot (1954) are then given, followed by a discussion of the effects of *balking* (refusal to wait). The distribution of the busy period is then derived. The case of constant service time is discussed next followed by *graded multiple systems* and finally by *systems in tandem*.

The last chapter on traffic measurements deals with certain results which have a bearing on the adequacy of the specification of the input and service distributions assumed to be given in the earlier chapters. Some results of V. E. Benes (1957), C. B. Clarke (1957), and of L. Kosten *et al* (1949) are given.

C. S. Ramakrishnan

Monetary Policy and Economic Growth : By H. V. R. Iengar, VII—295, Vora & Co., Publishers, Private Ltd., Bombay, 1962 ; Price Rs. 17.50.

1. The volume is a collection of twentyfive speeches and lectures by Shri H. V. R. Iengar delivered during the period 1957-1961.

2. Problems of central banking and monetary policy and the role of the Reserve Bank of India form the subject matter of a majority of these. A course of three lectures on the role of the Reserve Bank of India (RBI) in the planned economy delivered under the auspices of the National Bank of Egypt in 1960 gives a fairly long and illuminating account of the subject and it is difficult to imagine a better presentation of the topic. In two of the lectures, the working of the other banks has been considered in some details, and the problems of cooperatives form the subject matter of a couple of lectures. The other speeches in this broad field are concerned with the price situation, monetary stability and allied problems on the one hand and the specific role of the Central bank in relation to such problems on the other. In general, the author is not against a slightly inflationary situation. He feels that "there are sound economic arguments for saying that a reasonable price increase for a time, may actually be desirable, if it stimulates increased production" (p. 54). The rate of increase he envisages is 2 to 3 per cent per year (p. 254). He is of the view that "the (price) policy has........to be, at the same time expansionary as well as restrictive, the expansion and contraction being operated on different sectors of the economy" (p. 26). Finally, it is easy to agree with him when he states that "the strength of a currency depends on the inherent economic strength of a country and the way it conducts its economic and monetary affairs rather than on the volume of its gold and foreign exchange holding" (p. 32).

3. Some of the speeches are concerned with the general economic development in the country. A few of these relate to the immediate past and here naturally the author has dwelt on the role of economic planning for national development. One lecture and a speech, however, deal with economic growth in the country over historical periods.

4. The former group is more exciting and in these essays, Shri Iengar conveys a complete grasp of the subject matter. Some of the facts presented by him are new, not only to the lay reader but also to the initiated. To quote a trivial example, who would know that "the standard Oerlikon lathe for which the price in Switzerland is Rs. 33,000, is now being produced and sold in India at Rs. 29,500 still leaving a substantial profit ?" (p. 93). Further, one feels that the author had to think independently on these problems and what he is talking about is not just a discourse by an academician. Of course, this has become possible because he, in fact, had to be in the midst of everything as the Governor of the RBI. But it is one thing to feel and think, and it is another thing to convey this to the reader.

5. The author's remarks about planning are generally progressive. He thinks that, "in retrospect, it would be fair to say that Government's timing for the setting up of steel plants was incorrect ; if a steel plant had been put up during the First Plan period, not merely would we have got it cheaper but we could have saved considerable foreign exchange which was spent against the imports of steel." (p. 86). Again for the same reason, "...... after you make the steel, the proper thing to do is to make some of your machinery and machine tools......." (p. 16). As is well known, Professor Mahalanobis has also repeatedly made the same point. While discussing rural economics, he states, "The rapid growth of the community development staff has meant that they have moved increasingly further away from the original impetus and clarity of vision of the former small circle of

community development workers" (p. 99). Lastly, we may quote a sentence in which he has nicely put the basic human problem of planning : "There can be no progress if the rich accept the need for material welfare of the masses only on condition that their own way of life is not affected and the poor agree to the socialistic pattern only on the condition that they need not work hard and can throw away a sense of discipline" (p. 71).

6. His excursions into economic history show his width of interest, but these lectures do not carry the same amount of conviction, as his some other essays do. For example, it is difficult to agree with him when he states, "........it appears that between 1850 and 1901, per capita income declined substantially" (p. 112) in India. Also, his observations on the growth of per capita income between 1900-1945 (p. 250) may not be entirely correct. One feels that deeper analysis and fuller documentation are needed before one could pronounce on how the country grew during last fifty or hundred years.

7. A couple of speeches relate to fiscal policies and two others are concerned with international transactions of the Indian economy. These speeches are like his discourses on current history, and perhaps even more forceful because here the author's grasp is more pointed. Finally, two speeches relate to certain aspects of national income and allied topics.

8. It is extremely difficult to review a collection of essays or speeches. In a way, the task is to replace twenty five reviews by one and this cannot possibly be done in a completely satisfactory way. The other way would be to pick and choose, and review a few speeches in details and leave the others. We have chosen the former way and tried to say something about everything. The latter way probably is less satisfactory when one is dealing with speeches. When Shri Iengar was called upon to deliver an address or inaugurate a conference, it was not possible for him to keep on thinking about the possible remarks of an academic critic while preparing his speech. What was possible for him was to give an account of his current thinking on a particular subject, without going deeply into all its aspects. The present collection is highly informative and eminently readable, and this is because of his wide experience, receptive mind and analytical faculty. Even though he could not cover the whole ground, he always had some interesting information to convey, and this he did in a refreshing and lucid style.

M. Mukherjee

Early Developments in Mathematical Economics : By Reghinos D. Theocharis, MacMillan & Co. Ltd., London ; Price 28*s*.

In this monograph the author has attempted to provide for the first time a systematic account of the early evolution of mathematical economics. Readers of this book would discover that before Cournot there were a number of attempts to solve economic problems with the help of mathematical analysis and notice a discernible flow of thought in their work.

Starting with the work of Aristotle, who was perhaps the first to use mathematics in an economic argument, the author proceeds quickly to review the works of other early writers including Daniel Bernoulli. The contributions surveyed in this monograph have been arranged in seven sections according to the language used with, of course, a few exceptions. For example, the earliest contributions of the Italian school of logicians are presented in Section 2 while the German and the British contributions are discussed towards the end of the book.

Served with a foreward by Professor Robbins, this book will be welcome to students of economic history and to the specialist as an interesting reading. The basic ideas, however, have not been presented in this book chronologically and one is bound to find repetitive ideas though perhaps they were independently discovered. One would think whether it would not be equally appropriate to have organised the material under selected mathematical topics and enumerated different authors using somewhat similar reasoning irrespective of the language they used. Also, uniformity in the use of symbols is probably desirable for better understanding of a book like the one under review.

N. S. Iyengar

Measurement of Achievement in Mathematics — A Statistical Study on Effectiveness of Board and University Examinations in India : By A. K. Gayen, P. B. Nanda, R. K. Mathur, P. Duari, and N. Bhattacharyya. Ministry of Education, New Delhi, 1961 ; Non-priced.

Measurement of Achievement in Mathematics is the first of a series of studies on the effectiveness of Board and University Examinations in India. The purpose of these studies, which are being sponsored by the Ministry of Education in India, is to determine in what respects the present system of examinations may be improved. Since evaluation of students' achievement is based almost exclusively on performance in public examinations consisting primarily of essay type questions, the methodology and findings of the study are of considerable interest to the educator in Pakistan where a similar examination system prevails. The authors attempt more than an analysis of students' performance on the examinations and their assessment by examiners. They begin with the objectives of instruction which must be taken into account in framing the syllabus and in selecting test items for the examinations. The authors in their analysis take into account four factors : (a) the Syllabus (What is taught); (b) the Method of teaching (How it is taught); (c) the Question papers and the Answer-scripts (What is examined); and (d) the Method of assessment of candidates' performance (How it is examined). For example, they have attempted to determine to what extent concepts in the Syllabus are represented in the examination paper selected for study in the survey.

Of particular interest is the authors' attempt to apply statistical methods used in treating results of objective type examinations to the analysis of the results of essay type examinations. A considerable part of the report is devoted to analysis of individual question items with respect to their discriminating power and difficulty value, for derivations of which extended tools and techniques have been used. In estimating validity of the examination, the authors were faced with difficulty because the only available criterion data were the results of other examinations of the same type. Some question may be raised about the technique used in estimating the reliability of the examination chosen for study. However, the authors were well aware of the complexity of the problems involved and presented their findings and interpretations tentatively pending further research in this series. On the whole, the report merits serious study and discussion by educators and research workers concerned with similar problems.

Ghulam Jilani

Stichprobenverfahren in der Marktforschung : By von W. Heyn, Physica-Verlag, Würzburg.

This book treats the theoretical basis of sampling as well as the practical problems raised in connection with the choice of samples. After introducing the reader to the fundamental concepts of statistical counting, sampling etc., in a non-technical language, the author proceeds to give the formulae for calculating estimators, confidence intervals, and testing the variance. After that the author devotes some pages to stratified and multistage samplings. The treatment is simplified with the help of some examples.

The author commences the second part of the book (which deals with the practical problems raised during sampling) by pointing out that the sampling can seldom be carried out strictly according to the plan. He then recommends the market-investigator to find out certain information before the actual commencement of sampling. This information coming under six headings is then explained and clarified with examples.

Finally, a number of tables, such as ordinates of normal distribution, χ^2 distribution etc., are given in an appendix.

R. L. Brahmachary

CORRIGENDA

1. The Social Transformation for National Development : By P. C. Mahalanobis, *Sankhyā*, Series B, **25,** 49–66.

Page 49 : The words "Reprinted from a pamphlet issued in August 1962" are to be added in a footnote. Page 66 : The words "Paper received, August, 1962" at the end of the paper are to be deleted.

2. Recent Developments in the Organization of Science in India : By P. C. Mahalanobis, *Sankhyā*, Series B, **25,** 67–84.

Page 67 : The words "Reprinted from a report submitted to a Conference in Czechoslovakia in July 1959 and issued as a pamphlet in September 1959" are to be added in a footnote. Page 84 : The words "Paper received, September 1959" at the end of the paper are to be deleted.

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2 DEC 1964

SANKHYĀ : THE INDIAN JOURNAL OF STATISTICS

EDITORS : P. C. MAHALANOBIS, C. R. RAO

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